Report for 1927-28

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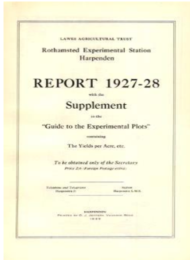
Rothamsted Experimental Station
Harpenden

REPORT 1927-28

Supplement

"Guide to the Experimental Plots"

Rothamsted Experimental Station Report for 1927-28 With the Supplement to the Guide to the Experimental Plots

Rothamsted Research

Rothamsted Research (1928) *Rothamsted Experimental Station Report for 1927-28 With the Supplement to the Guide to the Experimental Plots ;* Report For 1927-28, pp 1 - 176 **- DOI: https://doi.org/10.23637/ERADOC-1-85**

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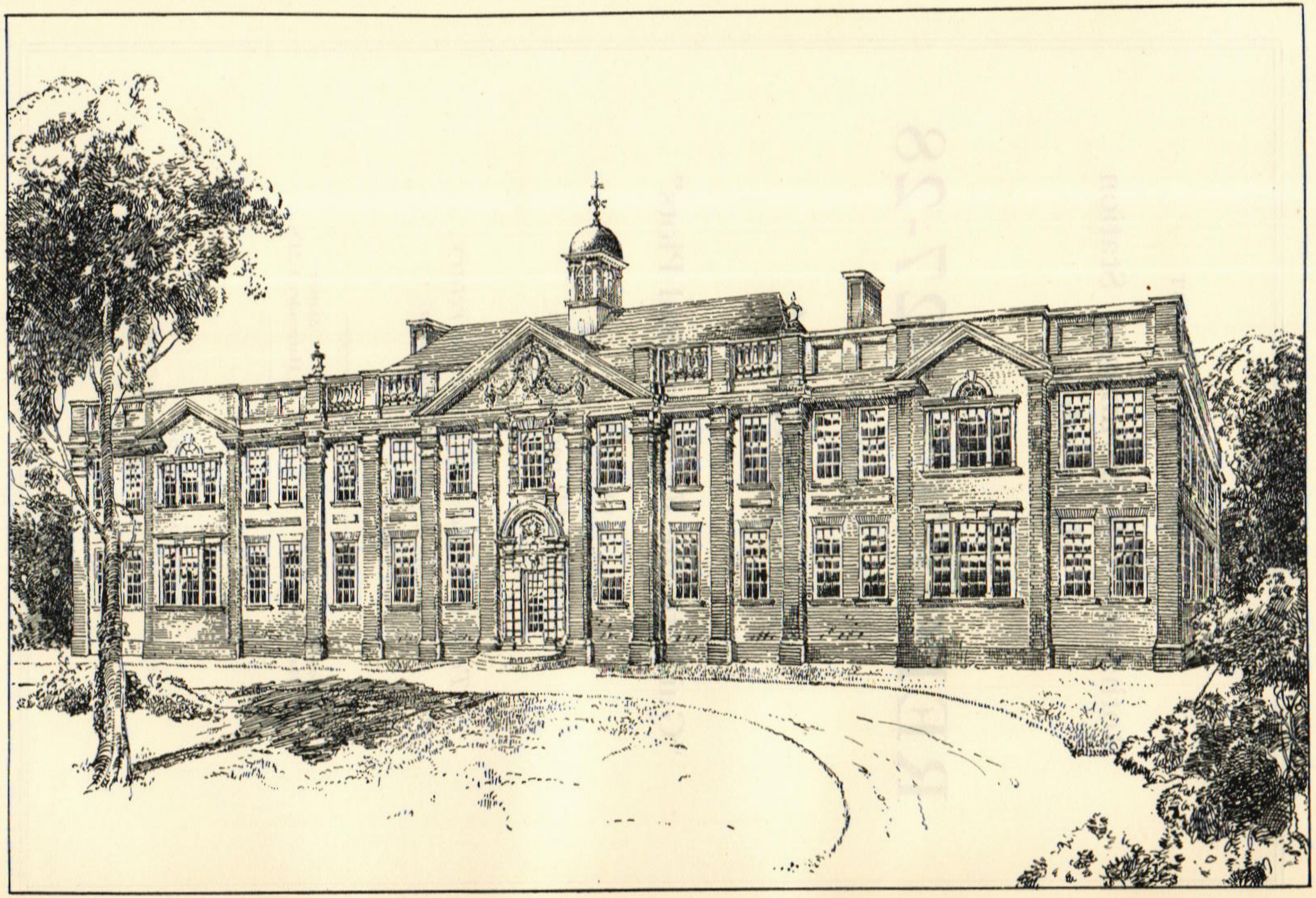

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REPORT

FOR

1927, 1928

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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.
Assistant Bacteriologist ...	P. H. H. GRAY, M.A.
Post - Graduate Research Worker	H. L. JENSEN.
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., A.Inst.P.
Assistant Chemists ...	R. G. WARREN, B.Sc. H. L. RICHARDSON, M.Sc., 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. PARBERRY, B.Sc.
Barley Investigations (Institute of Brewing Research Scheme) ...	L. R. BISHOP, M.A. F. E. DAY, B.Sc., F.I.C.
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Laboratory Attendants ...	MAUD BRACEY. ROSE ROBINSON.

Laboratory for Fermentation Work—

Head of Department ...	E. H. RICHARDS, B.Sc., F.I.C. (Iveagh Research Chemist).
Assistant Chemists ...	R. B. DAWSON, M.Sc. S. H. JENKINS, M.Sc., A.I.C.
Post Graduate Research Worker—	A. G. NORMAN, B.Sc., Ph.D.
Laboratory Attendant ...	MABEL PAYNE.

Laboratory for Insecticides and Fungicides—

Head of Department ...	F. TATTERSFIELD, D.Sc., F.I.C.
Assistant Chemist ...	R. P. HOBSON, B.Sc., Ph.D., A.I.C.
Laboratory Attendant ...	IRENE RANDALL.

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. H. SANDON, M.A. ANNIE DIXON, M.Sc., F.R.M.S. JANE MEIKLEJOHN, B.Sc. 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—	A. T. SEN, M.Sc.
Assistant	KATHLEEN ABBOTT.
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Laboratory Attendants ...	K. D. ANDERSON. MONA STAINES.

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.
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Research Worker (Honorary)	B. P. Scattergood, M.A.
Assistant Computers ...	A. D. Dunkley. Florence Pennells. Alice Kingham.

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.
Post Graduate Research Worker—	Marion A. Hamilton, B.Sc.
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Laboratory Attendants ...	Edith Cooper. Elizabeth Sibley.

Mycological Laboratory—

Head of Department ...	W. B. Brierley, D.Sc., F.L.S.
Assistant Mycologists ...	J. Henderson Smith, M.B., Ch.B., B.A. Mary D. Glynne, M.Sc. R. H. Stoughton, B.Sc., A.R.C.S., F.L.S. Mary S. Martin, B.Sc.
Glasshouse Superintendent	Margaret M. Browne.
Post Graduate Research Worker—	Phyllis H. Jarrett, M.Sc.
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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.
Assistant	G. F. Cole.

Plant Physiologists for Special Experiments (Imperial College of Science and Technology)	F. G. GREGORY, D.Sc. A. T. LEGG. F. J. RICHARDS, M.Sc. F. R. TUBBS, B.Sc., A.R.C.S. 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. T. LEWIS.
Stockman	H. S. HARPER.
Assistant Stockman ...	L. UNDERHILL.
Tractor Driver	J. UNDERHILL.
Labourers	W. HOLLAND. T. MISSENDEN.

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Assistant Secretary ...	CONSTANCE K. CATTON.
Director's Private Secretary	ANNIE E. MACKNESS.
Senior Clerk	BEATRICE E. ALLARD.
Junior Clerks	NORA LEVERTON. LUCY ARNOLD.

Photographer	V. STANSFIELD, F.R.P.S., F.R.M.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

W. C. Collett, N.D.A.	Assistant Trials Officer, Imperial Chemical Industries, Ltd., Agricultural Research Station, Jealott's Hill, Warfield, Bracknell, Berks.
J. Davidson, D.Sc., F.L.S.	Head of the Department of Entomology, Waite Agricultural Research Institute, Glen Osmond, Adelaide, South Australia.
W. M. Davies, Ph.D. ...	Adviser in Agricultural Zoology, University College of North Wales, Bangor.
Muriel L. Dick, B.A.	
T. Eden, M.Sc.	Senior Chemist, Tea Research Institute, Nuwara Eliya, Ceylon.
C. T. Gimingham, B.Sc., F.I.C.	Entomologist, Ministry of Agriculture and Fisheries, Pathological Laboratory, Milton Road, Harpenden.

W. B. HAINES, D.Sc., F.Inst.P.	Physicist and Head of the Soils Division, Rubber Research Institute, Kuala Lumpar, Malaya.
C. HEIGHAM, M.A. ...	Professor of Agriculture, Armstrong College, Newcastle-on-Tyne.
H. LLOYD HIND, B.Sc., F.I.C.	Research Organiser, Institute of Brewing Research Scheme.
H. J. G. HINES, B.Sc. ...	Lecturer in Agricultural Chemistry, University of Queensland, Brisbane.
W. O. JAMES, B.Sc. ...	Lecturer in Plant Physiology, University of Oxford.
WINIFRED A. MACKENZIE, M.Sc. (Econ.).	Married Rev. R. Tyrrell.
R. O. Millar	Farm Bailiff, Herts Farm Institute, Oaklands, St. Albans.
H. M. MORRIS, M.Sc. ...	Entomologist, Department of Agriculture, Nicosia, Cyprus.
H. J. PAGE, B.Sc., A.I.C.	Head of Research Laboratories and Chief Chemist, Imperial Chemical Industries, Ltd., Agricultural Research Station, Jealott's Hill Farm, Warfield, Bracknell, Berks.
W. A. ROACH, B.Sc., A.I.C.	Biochemist, East Malling Research Station, East Malling, Kent.
B. MURIEL BRISTOL ROACH, D.Sc.	

TEMPORARY WORKERS, 1927 and 1928

In addition to those temporary workers recorded in the List of Staff, the following have worked at the Station for various periods during the two years, 1927 and 1928 :—

SENT OFFICIALLY BY GOVERNMENTS AND CORPORATIONS :

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

Ministry of Agriculture Scholars : F. Crowther, E. E. Edwards, T. N. Hoblyn, G. V. Jacks, C. E. Marshall.

Colonial Office Agricultural Officers and Scholars : R. A. Altson (British Guiana), W. H. Beckett (Accra, Gold Coast Colony), G. C. Coull (Aburi, Gold Coast Colony), R. Coull (Aburi, Gold Coast Colony), N. Craig (Mauritius), G. H. Jones (Nigeria), A. E. S. McIntosh (Barbados), F. J. Martin (Sierra Leone), G. Milne (Tanganyika), A. J. Page (Burma), R. G. H. Wilshaw (Scholar), C. H. Wright (Ibadan, Nigeria).

Foreign Office : Major R. G. Archibald (Khartoum), Dr. H. C. Green (Khartoum), R. E. Massey (Khartoum).

Australian Government : H. W. Kerr (Brisbane).

Indian Government : Professor Balmukand (Punjab), K. M. Munir (Punjab).

New Zealand Government : R. E. R. Grimmett.

Empire Marketing Board : Dr. Magasanik (Palestine).

Empire Cotton Growing Corporation Officers and Scholars : J. B. Hutchinson (Trinidad), A. R. Lambert (Sudan), E. Lawrence (Nyassaland), W. S. Martin (Uganda), W. Allen, A. H. Lewis (Scholars).

Messrs. Nitram, Ltd. : G. E. Blackman, F. B. Marmoy.

Salter's Institute : C. G. Akhurst (Fellowship).

(2) *From Foreign Countries—*

International Education Board Fellows : Professor Dr. M. C. Arva (Roumania), Dr. Hans Glomme (Norway), Professor Dr. E. Handschin (Basle), H. L. Jensen (Denmark), A. Kalnins (Latvia).

Germany : Dr. W. Boehme.

Japan : Prof. H. Katagiri, Prof. O. K. Shiratori.

Norway : Ansulo Laddesal.

Palestine : Dr. Felix Menchikowski.

Siam : W. R. Ladell.

Sweden : Dr. G. Fortenssen, Dr. G. Giobel.

United States of America : Dr. R. Bradfield, Dr. Edith Patch.

VOLUNTARY WORKERS :

J. C. Baird, C. M. Blow, J. J. Brereton, H. Campbell, S. Dickinson, Miss D. E. Hazell, H. Henson, S. E. Jacobs (Imperial College of Science), H. J. Johnson, G. O. Lunnon (South Africa), Dr. M. A. P. Madge, Miss A. H. Pearce, E. Phillis, T. W. Simpson, J. G. Thomas, Dr. H. H. Storey (Natal), V. Subrahmanyan (India), Dr. A. Wulff (Java).

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.

"FARM SOIL AND ITS IMPROVEMENT," by E. J. Russell, 1923. Ernest Benn, Ltd., 8 Bouverie Street, London, E.C.4. 7/6.

ROTHAMSTED CONFERENCE REPORTS; being papers by practical farmers and scientific experts:

"THE MANURING OF POTATOES." 1/6.

"THE GROWING OF LUCERNE." 1/6.

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

"GREEN MANURING; ITS POSSIBILITIES AND LIMITATIONS IN PRACTICE." 2/–.

"THE CULTURE AND MANURING OF SUGAR BEET." 2/6.

"ART AND SCIENCE OF CULTIVATION." 2/–.

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

"MALTING BARLEY." 2/6.

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

"THE HERTFORDSHIRE AGRICULTURAL SITUATION: CAN IT BE IMPROVED." 2/–.

Ernest Benn, Ltd., 8 Bouverie Street, London, E.C.4; or 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.

https://doi.org/10.23637/ERADOC-1-85

"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. 1925. 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. 1925. Second Edition. Revised and Enlarged. 1928. 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. 1929. 6d.

"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. 2/- 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. 1919. The University Press, Cambridge. 8/–.

For use in Schools

"Lessons on Soil," by E. J. Russell. 1912. 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.

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 1927-28, the Ministry of Agriculture has made a grant of £26,959 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 Lady Ludlow, Sir Otto Beit, Mr. Robert Mond, Mr. T. H. Riches, Mr. and Mrs. D. McAlister and other donors have, from time to time, generously provided funds for special apparatus and equipment. Nitram, 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 Potash Syndicate, Messrs. Brunner Mond & Co., Fertiliser Sales, Beet Sugar Factories (Anglo-Dutch Group) and other firms, also give substantial assistance. The Empire Marketing Board, the Royal Agricultural Society and the Institute of Brewing, 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; a new block was erected in 1923 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

B

Gables, is now being converted into an Administration Building to hold the offices, 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 will make an annual grant of £2,345 for the study of virus diseases. The equipment of the Station is now exceptionally good.

The Library is steadily growing, and now contains some 21,000 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 Islands, 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 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 YEARS 1927-28

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 86 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.

While the purpose of the work has remained constant, its application has changed. For many years the application was to the increase of food production to ensure the feeding of the population of the world. The nineteenth century closed with distinct fears that population might outstrip food resources: in 1898, Sir William Crookes gave a closely reasoned address to the British Association showing that without altogether new developments there might be serious shortage about 1930. As the way out he indicated the possibilities of producing nitrogenous fertilisers from the air. This is now an accomplished fact; new sciences, among them plant genetics, have also developed, and food production has extended so greatly that all fear for the future has gone. Instead, a new tragedy has arisen: the farmers who have made the world's food safe have greatly reduced their own livelihood through the very success of their efforts. The present situation is without parallel in the history of agriculture.

The outstanding fact is that the price paid to the farmer for his produce is so near the actual cost of production that he has no margin for contingencies—indeed, his balance not infrequently comes out on the wrong side. Mere increases in crop do not help the situation: 1928 was one of the best of recent years for yield but, financially, among the most disastrous. The situation can be met by lowering the costs of production and by giving the farmer a more equitable share of what the consumer pays. With the marketing problem Rothamsted is not officially concerned: our business is to reduce, if possible, costs of production.

It is to costs of production, therefore, that the results of agricultural science are now being applied: to increase the output per unit of labour and of money put into the land, and to reduce wastes and losses. While the Rothamsted investigations are not directly turned to these ends, the information which they give is applied thereto, and it is extended and developed in such a way as to be of maximum service to those who are seeking to help the farmer.

Two important conferences were called at Rothamsted in the winter 1928-29 to discuss the agricultural situation. From these it was quite clear that the old four-course rotation is no longer a suitable basis for arable husbandry. Roots are too expensive and uncertain. Wheat-growing in general does not pay. This is not peculiar to England : one of the remarkable agricultural changes of the twentieth century is the shifting of wheat cultivation from the wetter to the drier regions of the world. It is taking place in Australia and Canada just as much as here : regions of 30-inch annual rainfall which produced wheat in the nineteenth century do so no longer : wheat has gone into regions of 24 inches or less. Here in England wheat is similarly being restricted more and more to the dry Eastern counties, where it will doubtless continue.

But it also appears that grass farming pure and simple, however well done, is no complete remedy. For the grass farmers must buy store animals in spring, and sell animals in summer and autumn : where too much land is in grass, prices of spring stores are forced too high and of autumn animals too low.

The new agriculture that is emerging out of the present series of changes includes the following features :—

(1) a closer connection between arable and grass land than formerly, especially an improvement in the grass and the lengthening of the grazing season; longer leys in arable regions and use of prolific fodder crops such as lucerne; the fattening of young animals on grass, as far as is practicable, instead of keeping them to be fattened during the following winter;

(2) the growth of cheap winter food for animals to ensure cheap production of milk in winter and to avoid the necessity for the present forced sales of unfinished animals in autumn;

(3) the substitution of crops of value, such as potatoes, sugar beet, Brussels sprouts, cabbages, etc., for the present root crops; extension of fruit growing and market gardening;

(4) improvements in the methods of fallowing;

(5) the use of poultry, pigs, etc., to complete the conversion of home-grown produce into more valuable products such as fresh meat and eggs, thus avoiding the necessity for forced sales of grain.

All these problems are being studied on the Rothamsted and Woburn farms, and the information yielded by the experiments is applied to them as rapidly as is possible.

CROP EXPERIMENTS.

Replacement of the Old Root Break.

Potatoes. If potatoes are to be grown at all they must be grown well, and in particular must be adequately fertilised.

Since 1921, an experiment has been made each year to discover the effects of sulphate of ammonia and sulphate of potash on potatoes : the results show that the two fertilisers are closely linked, and neither gives its best effect without the other. The results were, in tons per acre :—

Sulphate of Ammonia.		1927: 0 cwt. per acre	1927: 2 cwt. per acre	1927: 4 cwt. per acre		1928: 0 cwt. per acre	1928: 1½ cwt. per acre	1928: 3 cwt. per acre
Sulphate of Potash Cwt. per acre.	0	6.54	7.06	7.16	0	6.60	8.75	8.26
	2	6.56	7.74	7.85	1	7.67	9.03	11.05
	4	6.90	7.70	7.45	2	7.06	8.79	10.63

With sufficient potash and phosphate the increases given by 1 cwt. sulphate of ammonia per acre have been, at Rothamsted :—

Year.	Date of Planting.	Date of Lifting.	Yield without Sulphate of Ammonia Tons per acre.	Increase in cwt. for 1 cwt. Sulphate of Ammonia.
1925	April 25 ...	October 6 ...	7.25	24
1926	April 24 ...	October 21 ...	7.8	26
1927	May 23 ...	October 6 ...	6.5	10
1928	April 17 ...	October 19 ...	7.6	20

Excepting only in 1927, when the potatoes were set very late, the increases are round about the usual 20 cwt. per acre.

At Woburn, the increments have been more varied :—

Year.	Date of Planting.	Date of Lifting.	Yield without Sulphate of Ammonia Tons per acre.	Increase in cwt. for 1 cwt. Sulphate of Ammonia.
1926	May 10 ...	Oct. 11-12 ...	6.5	9
1927	June 25 ...	Oct. 27-28 ...	6.5	9
1928	May 5-9 ...	Oct. 24-26 ...	11.9	30

With sufficient sulphate of ammonia the increases given by 1cwt. sulphate of potash are much more variable : they have been, at Rothamsted :—

Year.	Date of planting.	Yield without Potash. Tons per acre. No dung.	Dung.	Increase for 1cwt. Sulphate of Potash. Cwt. No dung.	Dung.	Increase for 1 cwt. Muriate of Potash. Cwt. No dung.	Dung.	Hours of Sunshine, July, Aug., Sept.
1922	April 22-24 ...	2.48	9.21	58	20	67	18	379
1923	May 4-5 ...	9.73	11.70	25	10	30	23	668
1924	May 6-10 ...	6.20	9.18	10	No increase	9	6	523
1925	April 29–May 4	5.03	—	40-46	*	48	—	441
1926	April 23 ...	—	9.45	*	20-23	—	22	479
1927	May 23 ...	—	6.92	*	Depression	—	1½	420
1928	April 17-20 ...	—	7.69	*	—	—	28(1)	681

(1) Mean of muriate and 30 per cent. potash manure salts.
* No experiment made.

The effectiveness of the potassic fertiliser is lessened by late planting : indeed, for potatoes, as for sugar beet, we know of no profitable scheme of manuring a late planted crop.

Potassic fertilisers are clearly much more dependent on the season than nitrogenous fertilisers : the explanation is that they increase the efficiency of the leaf, an action which is advantageous

https://doi.org/10.23637/ERADOC-1-85

in sunless seasons; also they increase the vigour of the plant, thus helping it in seasons of spring drought or other difficulties.

Sulphate of potash in our experiments usually excels the other potassic fertilisers for yield, though not by much, muriate running it very close and the 30 per cent. potash salt is not far behind. The average yields, in tons per acre, of the last six years for the dressing of 2 cwt. sulphate of potash[1] per acre and equivalent amounts of the other salts, have been :—

	No Potash.	Sulphate of Potash.	Muriate of Potash.	Potash Manure Salts 30%.
1922	F.Y.M. 8.03	9.55	9.21	—
	no F.Y.M. 2.48	8.30	8.32	—
1923	F.Y.M. 11.70	12.47	13.03	12.07
	no F.Y.M. 9.73	12.23	12.00	11.43
1924	F.Y.M. 9.18	8.82	8.70	9.22
	no F.Y.M. 6.20	7.27	7.15	7.77
1925	no F.Y.M. 5.03	9.68	9.42	9.36
1926	F.Y.M. 9.45	11.36	11.52	10.97
1927	F.Y.M. 6.92	7.38	7.16	6.86
		7.35	7.04	6.46
				double dressing

F.Y.M. = Farmyard Manure.

The figures from 1925 onwards, when the new methods were introduced, have more value than those for the earlier years.

Superphosphate was included in the tests in 1928. The results show an average gain of 5 cwt. potatoes per cwt. of 36 per cent. superphosphate at Rothamsted, and the following at other centres, adequate supplies of sulphates of ammonia and of potash being given :—

Wisbech ... ... 3 cwt. potatoes.
Stowbridge ... ... 19 cwt. ,,
Woburn ... ... 8 cwt. ,,
Rothamsted ... ... 5 cwt. ,,
Aberystwyth ... ... Nil
Average : 7 cwt. potatoes per cwt. superphosphate.

At three of the five centres increases in yield continued (though not at this rate) up to 8 cwt. superphosphate, at one (Aberystwyth) there was no clear increase, and at one (in Lincolnshire) there was apparently a decrease : this is being more fully examined this year. The yields are given on pp. 143, 156, 170-4.[2]

The effect of the superphosphate is dependent on the presence of sufficient nitrogen and potash as shown in the following yields at Rothamsted in tons per acre :—

Varying nitrogen, adequate potash 1928.

	Sulphate of Ammonia. 0 cwt.	1½ cwt.	3 cwt.
With super	7.67	9.03	11.05
No super	7.62	9.15	9.76
Gain due to super	Nil	Nil	1.29

[1] Rather less on the farmyard manure plots of 1922, 3 and 4.
[2] Full Report.

Varying potash, adequate nitrogen 1928.

	Sulphate of Potash. 0 cwt.	1 cwt.	2 cwt.
With super	8.26	11.05	10.63
No super	8.00	9.76	9.74
Gain due to super (3-cwt. per acre)	0.26	1.29	0.89

It has now become possible to arrange for a satisfactory investigation into the influence of manuring on the quality and keeping value of potatoes. Dr. Lampitt, Head of Messrs. J. Lyons' laboratories, is conducting cooking tests (boiling and frying) of all our samples fresh from the field and after storage, and with his help we hope also to obtain the percentages of dry matter, starch, nitrogen and other constituents likely to influence quality.

Sugar Beet. The Beet Sugar Factories—Anglo-Dutch Group—generously made grants in 1927, 1928 and 1929, enabling us to carry out extensive fertiliser trials at Rothamsted and Woburn, and to repeat typical experiments elsewhere. These trials, being in much more detail than was previously possible, have brought out a number of important points, but they have also shown that we do not yet properly understand the manuring of sugar beet and, therefore, are not obtaining as large yields as we ought. The Continental recommendations which most farmers follow are not altogether suitable to English conditions.

In 1927, sowing was unavoidably delayed at Rothamsted and the purpose of the experiment was to discover whether in these conditions, which are always liable to arise in a heavy soil, any fertiliser scheme could make up for lost time. Unfortunately, none of the forms or combinations of nitrogen, potash, phosphate proved successful, and we do not yet know how to get over the difficulties of late sowing.

The other experiments of 1927 and those of 1928 were to discover the effects of the various fertilisers on the crop, both on roots and leaves, the latter being important as stock food.

The leaves behave normally towards fertilisers. Nitrogenous fertilisers deepen their colour and increase their size : an additional hundredweight of nitrate of soda gave about one ton of additional leaf per acre.

The roots, however, are much less affected than the leaves and are not nearly so responsive as mangolds. One ton of mangold leaf will commonly give about 4 to 6 tons of root, but one ton of sugar beet leaf may give only one ton of root and sometimes much less. Sulphate of ammonia applied with the seed had but little effect : muriate of ammonia was rather better, but nitrate of soda was best of all. None of the nitrogenous fertilisers, however, did much to increase the yield, while they all lowered the sugar content and the weight of root formed per 100 parts of leaf. Phosphate had but little effect either on yield or sugar content. Potassic fertilisers also had only little action, but, of these, potash manure salts was somewhat better than the muriate.

The results suggest that sodium, perhaps magnesium and chlorine, play some part in the nutrition of the sugar beet, and that the plant cannot make full growth unless they are supplied.

Rothamsted, 1928.

	Nitrogenous Top Dressing. Nitrochalk.		Potassic Fertilisers.		Phosphatic Fertilisers.	
	2 cwt.	4 cwt.	Muriate of Potash.	Potash Manure Salts.	None.	Super-Phosphate.
Roots, tons per acre	9.25	9.19	9.08	9.23	9.06	9.25
Tops, tons per acre	11.59	12.39	11.26	11.60	11.32	11.54
Sugar, per cent. in root	17.63	17.27	17.61	17.61	17.60	17.63

Woburn, 1928.

	Sulphate of Ammonia. No top dressing.	Muriate of Ammonia. No top dressing.	Sulphate of Ammonia and Nitrochalk.	Muriate of Ammonia and Nitrochalk.
Roots, tons per acre ...	13.82	14.42	14.00	15.10
Tops, tons per acre ...	11.47	11.98	12.49	13.59
Sugar, per cent. in root	18.07	18.00	18.22	17.76

The effect of nitrogenous manure in lowering the efficiency of the leaf as a producer of root is shown by the weight of root made by 100 of leaf :—

Top dressing (Nitrochalk) ...	None	Single dose	Double dose
Muriate of potash	89.4	78.6	73.8
Potash manure salts	88.6	80.5	73.0

The results are disappointing and show that we still have much to learn about the manuring of sugar beet, and about the varieties best suited to our conditions. Our present varieties come from the Continent, and in the long continued process of selection the search has been for roots rich in sugar suitable for the factory, but not necessarily for the farmers. As compared with the sugar beet grown sixty years ago at Rothamsted, the 1928 roots are much richer in sugar, but the yield per acre, both of roots and of sugar, has decreased, and the efficiency of the leaves has fallen considerably. The improvement has apparently been mainly a shrinkage in size of the root, thus compacting the sugar into a smaller space :—

Years.	Yield, tons per acre.		One ton of top made roots in tons.	Sugar.	
	Roots.	Tops.		Per cent. in root	Cwt. per acre.
1871-3 ...	18.9	5.1	3.7	11.0	41.6
1928 ...	9.4	12.2	0.8	17.6	33.1

Apparently there is room for considerable improvement, both in varieties and in management of this crop, the restricted response to fertilisers suggesting some kind of congestion in the plant; it is not always obtained: for example, at one of the outside centres (Durham) muriate of potash was distinctly effective, the yields being in tons per acre :—

No Potash.	Muriate of Potash, cwt. per acre. 1	1½	2
9.75	10.25	10.87	12.32

Each plot also received 1 cwt. sulphate of ammonia and 4 cwt. superphosphate per acre.
Increase per cwt. muriate of potash—20 cwt. sugar beet.

It is somewhat curious that the factory determinations of the percentage of sugar in the roots were consistently lower than ours made on samples taken direct from the field.

Cereals.

Under British conditions the most important fertilisers for cereals are the nitrogen compounds : these act with considerable uniformity, 1 cwt. sulphate of ammonia giving increases that range about 4½ bushels of wheat, 6 bushels of barley and 8 bushels of oats. The figures vary from season to season, but their relationships to the meteorological data are not yet fully known.

Barley. The experiments on barley are made in conjunction with the Institute of Brewing to ascertain the effect of soil, season and manuring on the yield and malting quality of barley. During 1927 and 1928 they have been continued at Rothamsted, Woburn, Wellingore (Lincs.), Chisleborough (S. Somerset), Fitzhead (Vale of Taunton) and Longniddry : they were, however, discontinued at the other centres, sufficient information having already been obtained. The most striking effect again was the increase given by 1 cwt. sulphate of ammonia per acre; this was greatest in years of low yield and least in years of high yield so that the effect of the fertiliser is to even up the results : the yields have been, in bushels per acre :—

	Lowest	Highest	Range of Variation
Without nitrogenous fertiliser	19.9	47.9	28.0
With nitrogenous fertiliser ...	32.5	44.4	11.9

So far as the data go, the increments of yield seem to be affected by :—

(1) sufficient rainfall in spring to allow of tillering proportionate to the nitrogen supply;

(2) sufficient sunshine in July to allow of head formation proportionate to the nitrogen supply.

The values of the increments for the past eight years have been at Rothamsted :—

	1923.	1927.	1924.	1928.	1921.	1925.	1922.	1926.
Increment of yield, bushels ...	12.6	10.4	7.7	7.0	6.8	6.0	5.0	−3.5
Yield without nitrogenous manure, bushels ...	19.9	23.6	22.1	28.6	27.2	25.0	31.0	47.9
Rainfall in inches :								
March ...	2.48	2.38	1.14	2.40	1.07	1.22	2.29	0.22
April	1.48	1.86	3.18	0.91	1.57	1.70	3.52	2.96
May	1.68	1.19	4.63	1.45	1.45	2.48	1.58	1.95
July sunshine hrs.	223.8	130.4	236.6	276.3	240.0	183.6	149.5	151.1

https://doi.org/10.23637/ERADOC-1-85

The high increments are associated with years of 3 to 4 inches March and April rain and 200 or more hours of July sunshine, 1927 being the only exception. A higher increment might have been expected in 1924, but the abnormally wet summer and autumn greatly encouraged the growth of weeds and protracted the harvest.

The New Nitrogenous Manures.

Four nitrogenous fertilisers have been compared in detail. The results were, at Rothamsted, for barley :—

	1927.				1928.			
	Grain, bushels per acre.		Straw, cwt. per acre.		Grain, bushels per acre.		Straw, cwt. per acre.	
	Single dose.	Double dose.	Single dose.	Double dose.	Single dose.	Double dose.	Single dose.	Double dose.
Sulphate of ammonia	34.0	37.8	20.4	22.2	35.5	34.6	32.1	34.5
Muriate of ammonia	36.2	47.0	20.0	27.0	34.6	37.5	31.3	36.2
Urea...	32.8	43.8	20.0	24.3	35.0	35.8	31.1	32.8
Cyanamide	36.0	35.8	20.8	20.7	33.4	37.5	28.8	33.8
No nitrogen ...	23.6		15.4		28.6		24.4	

All fertilisers markedly increase the yield, with muriate of ammonia coming out best as usual in 1927, and quite well in 1928. In both years cyanamide has done well : it was applied a few days before sowing. Urea does not come up to muriate of ammonia.

These nitrogenous manures act best when they are applied with the seed—cyanamide should go on even earlier. Used as top dressing, even ammonium nitrate (nitrochalk) is ineffective, and when given late it only raised the percentage of nitrogen in the grain.

Barley sown.	No top dressing.	Nitrochalk applied : May 12.	June 4.	June 19.
Grain, bushels per acre	31.1	30.8	33.0	31.4
Straw, cwt. per acre	30.1	31.9	32.1	29.5
Nitrogen per cent. in grain	2.075	2.118	2.110	2.160

Superphosphate on barley. The Hoosfield barley plots afford the best demonstration in the world of the effects of phosphate, potash and nitrogen starvation on the barley plant. In British practice, phosphate starvation is rare, the barley being grown only one or two years after a root crop which has been manured with a phosphatic fertiliser. The farmer is more interested in the other problem : the effect of doses of phosphate larger than are needed to supply the bare necessities of the plant. This depends very much on the season, but also on the soil. In the outside experiments the glacial drift soils at each of the three Norfolk centres have always responded to superphosphate. On other soils, however, the response varies from season to season : *e.g.*, at Rothamsted, a response was obtained in 1927, but hardly in 1928 :—

Rothamsted.

	Grain, bushels per acre. 1927.	1928.	Straw, cwt. per acre. 1927.	1928.
Superphosphate	35.0	33.6	20.7	30.3
No superphosphate	31.4	32.8	18.9	29.4
Effect of superphosphate	+3.6	+0.8	+1.8	+0.9

The figures for the straw vary in the same direction. No connection between the meteorological data and the response to phosphate has yet been traced.

Potassic fertilisers on barley. The effect of potassic fertiliser, like that of phosphate, is much less marked than that of nitrogenous fertiliser. Few soils, except perhaps the thin chalks and light sands, show signs of potash starvation, and it is not clear that excess of potash over and above a margin of safety is advantageous: indeed, in some seasons, especially the good ones, sulphate of potash appears to be harmful. During its 77 successive years under barley, Hoosfield has passed through three stages: the first, when sulphate of potash not infrequently reduced the yield; the second, when it had no effect; and the third, when it increased the yield, potash starvation having set in at the end of about 32 years. The yields of grain have been, in bushels per acre:—

	Plot.	Early years. 1st 8 yrs. 1852-59.	1863.	1864.	1865.	1866.	Mean of 40 years. 1852-91.	Mean of 8 years. 1908-15.	Mean of 12 years 1916-27.
Complete artificials	4A	45.4	55.4	55.4	46.5	47.0	43.5	40.4	32.0
No potash	2A	44.9	61.6	58.5	48.4	50.5	42.75	28.5	26.5
Difference[1]		+0.5	—6.2	—3.1	—1.9	—2.5	+0.75	+11.8	+5.5

(1) Sulphates of soda and of magnesia are also omitted as well as sulphate of potash, but other plots show that their effects are relatively small.

Sulphate of potash caused a marked depression in yield of malting barley at Rothamsted in 1924 and at certain of the outside centres in other years: this is not common, but it appears to be a true result. The present data suggest that:—

(1) in years of high spring rainfall and good ripening weather, *i.e.*, years favourable to the formation of well-matured grain of low nitrogen content, sulphate of potash may decrease the yield of barley;

(2) in years unfavourable to ripening, sulphate of potash has less depressing effect and may even raise the yield of barley.

These variations are of the same kind as for wheat and potatoes, on both of which sulphate of potash acts beneficially in unfavourable seasons, and has less effect in good seasons, the badness of the season being in each instance measured by the yield of crop receiving no potash.

Actual depression of crop, however, seems to be confined to barley, and apparently to sulphate of potash, for it has been observed with muriate of potash only in 1924; whether the chlorine ion is beneficial and the sulphate ion harmful, is not known.

Effect of Fertilisers on Composition and Quality of the Grain.

The percentage of nitrogen in the grain of barley depends on the amount of nitrogen the plant has taken from the soil and on the amount of carbohydrate it has synthesised during its growth. A high nitrogen uptake makes possible considerable growth and sufficient carbohydrate formation to over-balance the nitrogen: the grain then has a low nitrogen content. It depends on the favourableness of the conditions whether this possibility eventuates. Late sowing, or a check in growth due to drought, or a late supply of nitrogen to the plant, may so cut down the available time that the plant cannot make the necessary carbohydrate: the nitrogen content of the grain then becomes high. On the other hand, high rainfall in the weeks after sowing, by reducing the nitrate in the soil, but otherwise favouring growth, lowers the nitrogen content of the grain, as shown by the following data, obtained at Woburn :—

Nitrogen per cent.	2.01	1.95	1.71	1.57	1.23
Year	1925	1922	1923	1926	1924
Barley sown ...	March 31	April 19	April 10	March 4	March 11
Rainfall in inches after sowing.					
March ...	—	—	—	0.09	0.35
April ...	1.59	1.93	1.34	2.59	2.97
May 1st-15th inclusive	1.18	0.35	0.79	1.43	1.35

In sufficiently favourable conditions, sulphate of ammonia may still further increase the carbohydrate production and thus further reduce the proportion of nitrogen in the grain; in less favourable seasons, however, insufficient carbohydrate is produced and the nitrogen content of the grain may be raised. As the nitrogen content is already low in favourable and high in unfavourable seasons, it follows that sulphate of ammonia tends to lower the nitrogen content of the grain in years when it is low and to raise it in years when it is high. Larger quantities (2 cwt. per acre) tend to raise it in any case. The Rothamsted results have been :—

Percentage of Nitrogen in Grain.

	1925.	1926.	1927.	1928.	
No Nitrogen...	1.597	1.599	1.452	1.915	
				Single.	Double dressing.
Sulphate of Ammonia ...	1.585	1.711	1.442	2.029	2.220
Muriate of Ammonia ...	1.552	1.684	1.438	1.985	2.112

As in previous years muriate of ammonia gave grain of lower nitrogen content than sulphate of ammonia. Potassic fertilisers counteract to some extent the tendency for sulphate of ammonia to raise the percentage of nitrogen; at Woburn, in 1928, the percentages of nitrogen in the grain were :—

Effect of Sulphate of Ammonia. Superphosphate and Sulphate of Potash.		Effect of Sulphate of Potash. Superphosphate and Sulphate of Ammonia.		Sulphate of Ammonia and Sulphate of Potash. No Superphosphate.
+Sulphate of Ammonia.	No Sulphate of Ammonia.	+Sulphate of Potash.	No Sulphate of Potash.	
1.372	1.310	1.372	1.398	1.346

The nitrogen content of the barley, more than any other single factor, determines its malting value. It is closely connected with the amount of " extract " and with the diastatic power of the malt, the extract varying inversely and the diastatic power directly with the nitrogen : it has also more subtle effects.

The investigations by Mr. Bishop on the nitrogen compounds of the barley grain have reached an interesting stage. The proportions of hordein, glutelin, and salt-soluble compounds are all connected with the percentage of nitrogen in the grain : for different samples of the same variety (Plumage-Archer) the glutelin increases proportionately to the nitrogen, the hordein increases more rapidly, and the salt-soluble compounds less rapidly than the nitrogen. The relationships are the same, whether the variation results from changes in soil, season or manuring; it appears, therefore, that the ratio glutelin/nitrogen may be a varietal constant of considerable interest to the breeder of barley for quality, and this is being determined for some of the new barleys grown by the National Institute of Agricultural Botany : the barleys are also being malted by the experts of the Institute of Brewing.

The large number of analyses of British-grown barleys made in recent years at Rothamsted has shown that the grinding barleys are richer in protein than is usually supposed. The figure quoted in the standard British tables is 8.6 per cent. of protein, corresponding to 1.38 per cent. of nitrogen; our results show that the figures have been, for barleys which buyers would not take for malting :—

	Valuation 45/- and less	Valuation below 40/-
1922	1.72	1.76
1923	1.73	1.95
1925	1.86	2.16
1926	1.58	1.65
Mean	1.72	1.88
Protein on conventional basis ...	10.8%	11.8 %

The results show that less protein concentrates, such as decorticated cotton seed cake or meal, or decorticated ground nut cake, than is usually recommended, need be mixed with barley meal for feeding to farm animals.

Winter-Sown Oats and Wheat.

The experiments have given further information as to the effect of time of application of the sulphate of ammonia, and we are now able to sketch out the following as the probable facts. In its relation to nitrogen supply, the life of a cereal plant has two well-marked periods: the first, in which roots and tillers are formed but no heads; the second, in which heads develop on the tillers, but no more new tillers are formed. For autumn-sown cereals, the first stage is so long drawn out that it can be sub-divided into a first period, starting at the time of germination and continuing all through the winter, when root formation is the chief process, and a second period when tillering proceeds actively; at Rothamsted, this is mainly in the spring, about March, or early April. Roots, tillers and heads are all increased by nitrogen supply. The heads, however, are increased in number only, and not in size or number of grains: there is even a small tendency for the number of fertile grains to decrease.

Applied during the time of tillering (which at Rothamsted is about the month of March) the nitrogenous fertiliser increases the number of tillers.

Applied after tillering has ceased, it can still increase the amount of grain, and also the amount of straw, though not as much as if it had gone on early enough to increase the tillers also. The earlier application has therefore at first sight the advantage. It suffers, however, in that some of the nitrogen may be washed out by rain, leaving insufficient for the crop unless an excess has been added. In practice, the ordinary dressing of 1 cwt. sulphate of ammonia per acre is best applied late, as it gives more grain and but little less straw than if applied early, while the larger dressing of 2 cwt. sulphate of ammonia is best applied early, as it then gives considerably more straw and somewhat more grain than if applied late. The averages of all results for the four years 1925-28 have been :—

Increases over No Nitrogen.

	Grain.				Straw.			
	Single.		Double.		Single.		Double.	
	Early	Late	Early	Late	Early	Late	Early	Late
Sulphate of Ammonia.								
Oats (2 years)	5.8	8.1	9.4	10.8	7.1	6.6	14.0	8.7
Wheat (3 years)... ...	1.9	4.3	5.3	2.8	3.8	4.6	7.5	4 3
Mean of all Tests with Sulphate of Ammonia and Muriate of Ammonia ...	3.5	6.0	6.7	5.1	5.1	4.8	10.8	4.6

Muriate of ammonia gives substantially the same results as sulphate of ammonia. The details are as follows :—

	No Nitrogen	Grain, Bushels per Acre.							
		Sulphate of Ammonia.				Muriate of Ammonia.			
		Single dose.		Double dose.		Single dose.		Double dose.	
		Early.	Late.	Early.	Late.	Early.	Late.	Early.	Late.
Oats, 1925	49.6	59.4	64.2	66.4	69.3	61.6	—	62.3	—
Oats, 1926	75.4	77.2	77.0	77.4	77.3	78.8	82.4	77.6	78.4
Wheat, 1926	27.0	24.5	32.8	30.8	32.1	35.4	34.4	37.0	29.5
Wheat, 1927	44.2	49.5	44.0	51.0	49.9	44.0	49.3	50.1	48.9
Wheat, 1928	43.3	44.4	50.6	—	—	48.5	48.1	—	—

	No Nitrogen	Straw, Cwt. per Acre. Sulphate of Ammonia. Single dose. Early.	Late.	Double dose. Early.	Late.	Muriate of Ammonia. Single dose. Early.	Late.	Double dose. Early.	Late.
Oats, 1925	23.5	31.8	30.8	36.7	34.6	31.8	—	37.4	—
Oats, 1926	44.1	50.0	50.0	58.9	50.3	52.6	48.6	58.2	47.2
Wheat, 1926	41.3	43.7	44.9	46.2	46.7	46.4	44.8	50.3	43.1
Wheat, 1927	45.8	51.4	48.6	55.8	48.9	48.4	50.0	55.3	49.1
Wheat, 1928	29.2	32.5	36.7	—	—	33.3	33.7	—	—

Cereal mixtures for green feed, hay or silage, and therefore grown for leaf rather than grain, should receive their nitrogenous dressing during tillering time.

Nitrogen in wheat grain. An experiment was made in 1928 in conjunction with the Research Association of British Flour Millers to ascertain how far the nitrogen content of wheat can be altered by variations in time of application of nitrogenous fertiliser. No significant effect was produced by manuring, although there were differences between the varieties : Yeoman II and Square Head's Master both contained more nitrogen in the grain than Swedish Iron or Million III. The percentage of nitrogen in the dry grain was :—

Different Varieties.		*Different Times of Applying Nitrogenous Fertiliser.*	
Yeoman II	1.700	No nitrogenous fertiliser	1.646
Square Head's Master	1.698	Early top dressing ...	1.642
Million III	1.565	Late top dressing ...	1.639
Swedish Iron	1.539	Early and late top dressings	1.657

Grassland.

Grass presents special problems because it is not a single crop but a mixture, the members of which are competing with one another. Further, the value of grass is not sufficiently expressed by its weight : it depends not only on the kind of plant but on the way the plant grows, whether leafy or stemmy. Two qualities are important to the farmer : palatability and feeding value. Palatability is tested in the Woburn experiments in Broadmead, where grass is treated with lime, basic slag, superphosphate, potassium salts on separate unfenced plots, all of which are then grazed by animals free to wander where they will. They congregate on the most palatable herbage and leave the rest : they choose always the plots treated with lime and phosphate. Feeding value is tested at Rothamsted; the plots are fenced in and the animals are given no option as to where they shall go : they are weighed each fortnight. The results again show the value of phosphate, especially the basic slag of high solubility : within certain limits they show that a 2 per cent. solution of citric acid is a useful agent for estimating agricultural value, though others are being tested with promising results. The experiments have emphasised the importance of skilful and close grazing in the management of grassland; this is even more important than manuring and, indeed, some of the records show that a properly manured pasture badly grazed may be worse than one left unmanured.

Grazing experiments are, however, the most unsatisfactory of all field trials; they are crude and liable to gross errors. They answer well enough to show strikingly obvious differences, such as those obtained at Cockle Park; and, with proper precautions to ensure success, they can make effective demonstrations, but they give little or no information beyond what a competent grazier could deduce on mere inspection of the herbage. The variations in the individual animals, the marked difference in results according as one more or one less is put on a particular plot, and the impossibility of allowing for their maintenance requirements, complicate a problem already rendered difficult by the variations in the land itself. We are endeavouring, during the present season. to improve the method so as to make it yield more useful results. We are also testing the mowing method used successfully in certain investigations.

The results have given some interesting measurements to show what grassland can do in various parts of the country. The live weight increases in pounds per acre of the sheep grazed on the unmanured plots have been :—

	Leicestershire. Thrussington.	Somersetshire. Fiddington.	Hertfordshire. Rothamsted.
1921–4	—	—	115
1925...	133.8	242	81*
1926...	217.0	187	204
1927...	274.6	297	—
1928...	203.8	428	91*
Average	207.3	313	

* Part of Season only.

The live weight increases on the slag plots at Rothamsted when that on the unmanured is put at 100 are :—

Per cent. soluble in Citric Acid.	81	77	71		28	Gafsa.
Average—						
1921-4	98	112	141	128	100	99
1925	95	127	90	168	59	123
1926	112	110	104	104	104	95
1928	94	112	109	109	115	125
Mean	99	114	124	128	95	105

The first dressing was given in 1921, and the plots were redressed in 1925.

Much clearer results are obtained in the manuring of hay land. Experiments on this subject were begun in 1856 on grass which even then was very old, and they have been continued ever since, the land being hayed every year, two crops being taken without grazing. The results are given on pp. 126-7[1]; they show the importance of potassic and phosphatic fertilisers for ensuring quality, and of nitrogenous fertilisers for giving bulk and early growth.

The effect of slag depends on its solubility: slags of 60 per cent. or more solubility in the 2 per cent. citric acid solution are

[1] Full Report.

more effective than those of 40 per cent. or less. The results were :—

	Yield, cwt. per acre : No manure.		Improvement given by slag. Yield when unmanured=100.			
			Enmore, Somerset. Solubility.		Brooke, Norfolk. Solubility.	
	Old meadow. Enmore, Somerset.	New ley. Brooke, Norfolk.	37%	87%	37%	87%
1926 ...	27.4	45.7	109	112	100	116
1927 ...	26.1	18.8	115	123	133	169
1928 ...	9.4	14.9	119	125	128	171

The rapid fall in yield of hay from the new ley is characteristic of the Eastern counties, and illustrates one of the difficulties of grassland farming there.

The experiments show that the old citric solubility test is of considerable practical utility in discriminating between the various slags now offered to the farmer, and they show the wisdom of insisting on a high solubility in general. Low soluble slags may serve a useful purpose in special conditions, but they should be bought only when the farmer has good reason to know that they will act well.

Fallow.

One of the most striking of recent changes in agriculture has been the increase in land under bare fallow. This represents a loss of crop in the current year, but a gain, and sometimes a marked gain, in the next, so that it is not necessarily as wasteful as it appears. The fallowing of part of Broadbalk has given us opportunities of observing some of the results : on part of it that has had a two years' fallow, the yields have been :—

	Plot.	1928.		Average 77 years, 1852-1928.	
		Grain. Bushels per acre.	Straw. Cwt. per acre.	Grain. Bushels per acre.	Straw. Cwt. per acre.
No manure since 1839	3	27.9	27.8	11.8	9.9
Complete artificials	13	55.2	32.0	29.2	30.8
No potash	11	56.9	31.4	21.4	21.8
No potash or phosphate	10	47.0	25.8	18.8	18.1
No nitrogen ...	5	35.2	34.8	13.6	10.6
Farmyard manure ...	2B	48.4	61.4	33.2	34.5

The result is a remarkable increase in the yield of grain and in the proportion of grain to straw. Never in the 86 years of successive wheat growing has Broadbalk grown a crop so thick set with grain, and we are unable at present to explain it. The season was very favourable, but probably not more so than some of the great wheat seasons of the past, 1854, 1857, 1863, 1894, yet in none of these was so much grain produced. Much of the effect is probably attributable to the fallow, but whether the action is the suppression of weeds, the decomposition of vegetable and other matter, or some physical change in the soil, we cannot decide. Something more seems to be involved than an increase in plant nutrients, for no fertiliser scheme we have yet tested produces this great increase in the proportion of grain. The ordinary fertilisers increase both grain and straw : the fallowing somehow caused the plant to produce grain and not straw. The investigation is being continued.

LUCERNE.

The value of lucerne as fodder is well recognised, but only a comparatively small area has hitherto been grown, and this is mainly restricted to the south-eastern part of England: elsewhere it often fails to survive. Investigations made by Mr. Thornton during the past five years have revealed both the cause and the remedy. Like other leguminous plants, lucerne is dependent on the bacteria living in the nodules of its roots, and as these are not normally carried in the seed they must enter the plant from the soil: if they do not occur there, the plant fails to grow well. The experiments show that the organisms are absent from many of the soils of the north and west of England, but they occur in the home counties and East Anglia, where lucerne has been grown for many years: they occur also, though probably in smaller numbers, in the flat region stretching away from the home counties to Cheshire—the region known to geographers as the Midland Gate. Mr. Thornton has developed a method of adding the necessary organisms by a process of inoculation which is both successful and inexpensive, increasing the yield of crops by 20 per cent. or more in districts where the appropriate bacteria are absent from the soil, and usually increasing the nitrogen content and therefore the feeding value. Inoculated lucerne seems to have as good a chance of survival in the north and west as in its old home in the south-east and East Anglia. Inoculation is particularly advantageous where lucerne is sown with a cover crop.

Inoculation, however, is not the only thing necessary to ensure success. Lucerne is very liable to weed infestation, in spring with the usual annuals, in autumn with special weeds like groundsel and chickweed. Trials showed no advantage, however, in delaying the sowing for the sake of extra cleaning: spring sowing in a cover crop has given the best results in our trials as widely separated as Somerset, Monmouth, Montgomery, Cumberland and Rothamsted.

Soil acidity is a potent cause of failure of lucerne, being harmful both to the plant and the organism. Acid soils must be limed before inoculation. Alway has obtained evidence that in Minnesota a second crop of lucerne sown immediately after the ploughing in of a first crop that has partially failed has a greater chance of success. No evidence for this was found at Rothamsted, nor of any acid resistant strain of organism that could be used on acid soils. Up to the present liming remains the only way of making an acid soil fit for lucerne.

Mr. Thornton, assisted by Mr. P. H. H. Gray and by generous grants from the Research Fund of the Royal Agricultural Society of England, has developed methods for preparing cultures of the bacteria on a large scale for distribution to farmers; he has also worked out a simple and effective way of putting the cultures on to the seed. The bacteria travel safely and are still vigorous at the end of their journey: indeed a package of them is being sent round the world to see if they will tolerate the 12 weeks of travel thereby involved. The cultures can be kept on the farm for at least two months before they need be used.

Although no advertising has been attempted the demand for cultures has increased rapidly. In 1927, 900 were sold, sufficient to inoculate 6,300 lb. of seed. In 1928, the cultures were further improved so that each one would inoculate twice as much seed: 1,750 were sold, representing 24,500 lb. of seed or nearly 1,000 acres of lucerne. The business of selling cultures, however, is not suited to the Rothamsted organisation; it is, therefore, being handed over to a trustworthy and efficient firm who are undertaking to keep close touch with the Rothamsted workers and embody in the process such improvements as from time to time may be effected.

THE ACCURACY OF THE FIELD EXPERIMENTS.

A new method of field experiments was introduced here in 1925 and has been used exclusively in all the new field experiments both at Rothamsted and at Woburn. Its purpose is to get over the difficulty of soil variation, and to measure the probability that the result is due to the treatment and not to soil differences or mistakes by workers. Dr. R. A. Fisher and the staff of the Statistical Department have worked out suitable arrangements of plots, the most convenient in practice being a grouping into blocks each of which contains one each of the proposed treatments, or into a latin square, each row and each column of which contains one, but no more, of each treatment. From the figures for yield, a standard error is worked out which shows the degree of trustworthiness of the result. A difference in yield equal to the standard error of this difference can be obtained about once in three trials even when the experimenter is convinced that he has given exactly the same manuring and cultivation to each of the plots, but a difference twice this size would be obtained by chance only once in 22 times: it is therefore much more likely to be true. The chances against the difference in yield being due to causes other than the difference in treatment are:—

For difference	equal to its Standard	error	...	3 to 1
,, ,,	double ,,	,,	...	22 to 1
,, ,,	three times	,,	...	370 to 1
,, ,,	four times	,,	...	15,780 to 1

For most agricultural purposes a chance of about 30 to 1 is good enough. The " standard errors " given in the following tables are those for the yield values, and they have to be multiplied by 1·414 (*i.e.*, $\surd 2$) in order to give the standard error of the difference between treated and untreated plots—the figure one usually wants. To attain a probability of 30 to 1, a difference must be roughly three times the standard error given in the tables. [1]

The method necessitates a large number of plots: during the year 1928 there were at Rothamsted and Woburn:—

Cereals	240
Potatoes	250
Sugar Beet	222

Remarkable accuracy can, however, be obtained: in 1927, the potato experiment of eighty-one plots testing different quantities of nitrogen and different quantities and kinds of potassic fertiliser had a standard error of only 1.14 per cent. The values for all the experiments so far done are given in Table 1.

[1] Full Report.

TABLE I.

Standard errors per plot, and of average results in the REPLICATED EXPERIMENTS, 1925-28, ROTHAMSTED and WOBURN.

Year and Page in Report.	Crop and Field.	Nature of Experiment, Fertilisers tested.	Area.	Number of Plots.		Standard error per plot, %	Standard error of means, %
1925, p. 138	Potatoes, West Barnfield	Potassic	1/50	16		4.9	2.4
1925, p. 139	Potatoes, West Barnfield	Potassic and S./A., varying quantities	1/50	48		8.6	4.3
1925, p. 144	Mangolds, West Barnfield	S./Amm. basal and Top Dressed	1/20	18	roots	14.8	10.5
					tops	10.8	7.7
1925, p. 145	Oats, Long Hoos	S. & M./Amm., Early and Late	1/40	24	grain	8.9	4.5
		Single and Double			straw	4.8	2.4
1925, p. 154	Wheat, Sawyer's Field	Uniformity Trial	1/10	47	grain	4.2	4.2
					straw	3.9	3.9
1926, p. 138	Potatoes, Stackyard	Potassic	1/50	16		3.8	1.9
1926, p. 140	Potatoes, Stackyard	Potassic and S./Amm., varying quantities	1/50	64		11.0	5.5
1926, p. 155[1]	Potatoes, Woburn	Nitrogenous, varying quantities	1/50	25		6.1	2.7
1926, p. 141	Sugar Beet, Woburn	Potassic	1/60	25	roots	4.3	1.9
					tops	8.5	3.8
1926, p. 142	Sugar Beet, Rothamsted	Nitrate of Soda Top Dressing	1/145	16	roots	3.5	1.7
					tops	4.1	2.1
1926, p. 143	Sugar Beet, Woburn	Nitrate of Soda Top Dressing	1/60	25	roots	14.5	6.5
					tops	15.0	6.7
1926, p. 146	Oats, Long Hoos	S. & M./Amm., Early and Late	1/40	96	grain	7.9	1.4, 2.0
		Single and Double			straw	12.5	2.2, 3.1
1926, p. 147	Wheat, Gt. Harpenden	S. & M./Amm., Early and Late	1/40	48	grain	14.0	3.5, 5.0
		Single and Double			straw	10.4	2.6, 3.7
1926, p. 149	Malting Barley, New Zealand	S. & M./Amm. Sulphate & Muriate of Potash	1/25	32	grain	9.0	4.5
					straw	5.0	2.5
1926, p. 150	Oats, Long Hoos	S. & M./Amm., Urea	1/40	12	grain	6.4	3.7
					straw	4.4	2.6
1926, p. 153	Swedes, Sawyer's Field	Cultivation	1/4	9	roots	6.5	3.8
					number	10.8	6.2
1926, p. 155	Swedes, Sawyer's Field	Uniformity Trial	1/10	47	roots	6.7	6.7
					tops	16.4	16.4
					number	7.7	7.7
1927, p. 135	Wheat, Great Knott	S. & M./Amm., Early and Late	1/40	48	grain	11.6	2.9, 4.1
		Single and Double			straw	8.6	2.1, 3.0
1927, p. 131	Barley, Gt. Harpenden	Nitrogenous, varying quantities	1/40	48	grain	10.3	2.1, 5.2
		Superphosphate			straw	10.7	2.2, 5.4
1927, p. 140	Potatoes, Long Hoos	Potassic and S./Amm., varying quantities	1/40	81		6.1	1.2, 1.4, 2.0
1927, p. 157	Potatoes, Woburn	Nitrogenous	1/40	36		7.4	3.7
1927, p. 156	Potatoes, Woburn	Superphosphate	1/40	16		5.2	2.6
1927, p. 150	Swedes, Long Hoos	Phosphatic and Nitrogenous	1/25	25	roots	3.2	1.4
					tops	5.2	2.3

[1] 1927–28 Report.

REPLICATED EXPERIMENTS, 1925-28—*contd.*

Year and Page in Report.	Crop and Field.	Nature of Experiment, Fertilisers tested.	Area.	Number of Plots.		Standard error per Plot, per cent.	Standard error of means, per cent.
1927, p. 144	Sugar Beet, Long Hoos ...	S./Amm. & Cyan., with Top Dressing ...	1/40	72	roots	10.2	1.5, 4.1
					tops	10.9	1.5, 4.4
1927, p. 160	Sugar Beet, Woburn... ...	Nitrogenous, varying quantities	1/40	54	roots	13.7	5.6
					tops	17.2	7.0
1927, p. 153	Oats, Sawyer's Field... ...	Uniformity Trial	1/10	47	grain	10.6	10.6
					straw	7.7	7.7
1927, p. 151	Barley, Sawyer's Field ...	Cultivation, Simar, etc.	11/40	9	grain	8.5	4.9
					straw	4.1	2.4
1928, p. 136	Wheat, Pastures	S. & M./Amm., Early and Late	1/40	96	grain	12.5	2.9
		Single and Double		(72 used)	straw	15.6	3.7
1928, p. 133	Barley, Long Hoos	Nitrogenous, varying quantities	1/40	96	grain	10.1	3.6
		Superphosphate...			straw	8.9	3.1
1928, p. 142	Potatoes, Gt. Harpenden ...	Potassic and Nitrogenous	1/90	162		9.4	1.3, 3.8
		Superphosphate...		(54 used)			
1928, p. 158	Potatoes, Woburn	Nitrogenous	1/40	72		7.1	2.5
1928, p. 156	Potatoes, Woburn	Superphosphate...	1/40	16		4.0	2.0
1928, p. 154	Malting Barley, Woburn ...	Nitrogenous and Potassic	1/40	32	grain	22.5	11.3
		Superphosphate...			straw	19.4	9.7
1928, p. 147	Sugar Beet, Gt. Harpenden...	Potassic, Superphosphate	3/200	144	roots	9.6	1.1, 1.4
		Top Dressing of Nitrochalk			tops	10.0	1.1, 1.4
1928, p. 162	Sugar Beet, Woburn... ...	Nitrogenous, Top Dressing of Nitrochalk ...	1/40	78	roots	9.3	2.2
					tops	15.1	3.6
1928, p. 139	Barley, Long Hoos	Nitrogenous Top Dressing	1/40	16	grain	7.7	3.8
					straw	7.2	3.6
1928, p. 152	Swedes, Gt. Harpenden ...	Cultivation, Ridged and Simar	1/20	16	roots	4.8	2.4
					tops	12.1	6.0

Average Standard Errors of Single Plot for Different Crops obtained from above table.

No. of Experiments on which Average is based.	Crop.		Average Standard Error of Single Plot. per cent.
11	Potatoes ...		6.69
7	Sugar Beet ...	roots	9.30
		tops	11.54
5	Swedes ...	roots	7.20
	or Mangolds ...	tops	11.06
4	Wheat ...	grain	10.58
		straw... ...	9.62
5	Barley ...	grain	9.12*
		straw... ...	7.18*
4	Oats	grain	8.45
		straw... ...	7.35

* But if Woburn, 1928, be included, these become 11.35 and 9.22 respectively; see page 154 of Report.

The standard error per plot is, for a number of the experiments, about 5 per cent. of the average yield; for others, including those on mangolds and sugar beet, about 10-15 per cent., the larger errors being at Woburn. One of the many advantages of the method is to show up the faulty experiments and so indicate the need for improvement. Thus the increased error in the wheat and potato experiments at Rothamsted in 1928 as compared with 1927, was traced to certain special circumstances which were fully investigated and will be sedulously avoided in future. The increased error for the Woburn barley in 1928 has not yet been explained.

The large number of plots treated alike in any one experiment enables the average yield for this treatment to be determined much more accurately than could be done with only one plot. Consequently, the " Standard error of the mean," the figure which is quoted in the summaries of results of experiments (pp. 131-175[1]) and which varies inversely with the square root of the number of plot yields averaged, is much lower than the standard error of a single plot, as is seen by comparing the two adjoining columns of the Table. It is, for many of the experiments, only 1½ to 3 per cent., while for most it is less than 5 per cent.

Efforts are now being made to improve the accuracy still further by eliminating the waste occurring at harvest and during cartage and storing : a method has been worked out in the Plant Physiological and Statistical Departments which has the further advantage of reducing the labour of harvesting; it consists in taking, just before harvest, a large number of samples from measured lengths of the rows, chosen at random, weighing them, and, for cereals, threshing in a miniature machine. The rest of the crop is then left to be harvested in the usual way, but no measurements need now be taken : the whole labour of separate harvesting, separate stacking, and separate threshing, with all the losses involved, is eliminated. A comparison of the new with the old method was made last year and will be carried out on a much larger scale this year : at present, the method seems distinctly promising in providing more accurate figures, better samples for analysis, and speedier results than could be obtained before.

The great advantage of knowing the standard error is that the figures for yield can be safely used for a wide range of purposes.

At present, they are being correlated with the meteorological data, the methods of collection of which have been constantly improved. This enquiry has been extended beyond the scope of our own station. Dr. Fisher has developed appropriate statistical methods for working up the masses of meteorological and crop data that have already accumulated in this country, aided by Dr. Wishart, who has supplied tables for testing the significance of results reached by means of these methods, while Mr. J. O. Irwin, working under the Ministry of Agriculture Crop Recording Scheme, is studying the problems connected with the technique of observation.

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[1] Full Report.

PLANT GROWTH AND QUANTITY OF FERTILISERS.

Of the many attempts to find the relationship between the amount of plant growth and the quantity of fertiliser applied, the most widely discussed is the attractive one of E. A. Mitscherlich, which, however, is open to some criticism. Professor Balmukand, working in Dr. Fisher's laboratory, has shown that the results may be expressed in terms of two constants, one representing the importance of the nutrient to the crop, while the other represents the amount of nutrient the crop can extract from the unmanured soil. The first of these constants is presumably a crop and even a varietal factor, and the second is a soil factor : the constants promise to afford a means of estimating both, and so of expressing numerically both the crop need and the amount of available plant food in the soil.

DETAILED LABORATORY AND POT CULTURE INVESTIGATIONS ON FERTILISERS.

The laboratory work is carried out in the Chemical Department by Mr. R. G. Warren and Dr. H. L. Richardson, under Dr. E. M. Crowther, and the pot culture work by Dr. W. E. Brenchley and Miss K. Warington.

Cyanamide. No experiments had been made at Rothamsted with this substance since 1920 and, as the method of manufacture has considerably altered, an extended series of investigations was begun in 1927 and is being continued. The modern material is practically free from the dicyanodiamide which used to cause much trouble, and it is also easier to handle than the old samples : it still needs, however, to be applied a few days before sowing. In our experiments, it has been as effective as sulphate of ammonia on barley at Rothamsted, but less on potatoes at Woburn and sugar beet at Colchester. The increments in crops for 1 and 2 doses of cyanamide and of sulphate of ammonia have been :—

	No Nitrogen.	One dose.			Two doses.			Cyanamide value when Sulphate of ammonia = 100	Urea value when Sulphate of ammonia = 100
	bushels	Sulphate of ammonia	Cyanamide	Urea	Sulphate of ammonia	Cyanamide	Urea		
Rothamsted.									
Barley, bushels.									
1927	23.6	10.4	12.4	9.2	14.2	12.3	20.2		
1928	28.6	7.0	4.8	6.4	6.0	8.9	7.2		
Additional bushels per lb. nitrogen.									
1927	—	0.45	0.54	0.40	0.31	0.27	0.44	106	110
1928	—	0.31	0.21	0.28	0.13	0.19	0.16	94	100
Woburn.									
Potatoes	tons.	cwt.	cwt.		cwt.	cwt.			
1926	6.50	17.6	15.2	—	27.2	25.0	—		
1927	6.53	12.8	7.2	11.0	−2.0	4.0	8.0		
1928	11.9	44.4	16.6	—	—	—	—		
Additional cwts. per lb. nitrogen.									
1926	—	0.76	0.66	—	0.59	0.54	—	89	—
1927	—	0.37	0.21	0.32	−0.03	0.06	0.12	79[1]	129
1928	—	1.29	0.48	—	—	—	—	37	—
Colchester.									
Sugar beet.	tons.				tons.	tons.			
1928	6.09	—	—	—	1.32	0.70	—		
Additional cwts. per lb. nitrogen ...	—	—	—	—	0.44	0.23	—	52	—

[1] Single dressing.

https://doi.org/10.23637/ERADOC-1-85

The comparison is made on the basis of the increments and not of the yield figures: it therefore carries all the errors of the experiments and acquires validity only as data accumulate. The very low value at Woburn in 1928 is probably fictitious and arises from the circumstances that the increment for sulphate of ammonia was abnormally high, being indeed the highest we have ever obtained.

Much work has been done in the Chemical Department by Dr. E. M. Crowther and Dr. H. L. Richardson on the decomposition of cyanamide in soil. The first reaction giving urea is brought about by some chemical change not understood: the urea then changes rapidly to ammonia and this, through the action of micro-organisms, is oxidised to nitrate.

While the general course of the decomposition is probably the same in all soils, the rate at which it proceeds varies in different soils. The most striking result is the delay in the formation of nitrate even after all the cyanamide has decomposed: the ammonia remains unnitrified for some long time. In spite of this, however, plants make good growth, suggesting that they are using the ammonia.

Ammonium Chloride.—The experiments described in the preceding pages and the earlier reports, show that ammonium chloride is, in general, superior to ammonium sulphate in equivalent amounts for cereals and, so far as the experiments have gone, for sugar beet but not for potatoes. Further information is being accumulated.

Urea. This substance compares very favourably with sulphate of ammonia in equivalent quantities; it has the advantage of high concentration, containing 46 per cent. of nitrogen against only 20.6 in sulphate of ammonia. Further, it has less tendency to make soil acid.

Basic Slag. Mr. R. G. Warren has shown that a solution of sodium chloride affords a better means of assessing the agricultural value of basic slag than the official 2 per cent. citric acid. Basic slag increased the amount of manganese in the barley grown in pot experiments: if it did the same for oats it might be expected to cure the "grey fleck" disease, which is attributed to deficiency of manganese. The manganese in the slag, however, did not appear to increase the yield of barley.

Superphosphate. In spite of much experimental work by the staff of the Chemical Department, no indication can be found that superphosphate ever makes a soil acid. Farmers in the west country and in the north maintain that it increases the liability to finger and toe in swedes: on this we have hitherto been unable to make experiments.

Dr. Brenchley has shown (in confirmation of Gericke's earlier work) that barley utilises phosphate for increased growth only in its early stages of growth, although absorption of phosphate continues almost throughout the whole life of the plant. Early sown barley can utilise phosphate for at least 12 weeks (varying with different varieties) while later sown barley cannot, its period of utilisation being shorter. Further, the period during which phosphate can be withheld without injury is longer for early sown than for late sown barley. These advantages in favour of early sowing have not previously been recognised.

Sodium Silicate. Sodium silicate has long been shown to benefit the barley crop at Rothamsted : evidence is now obtained that this is due to an action in the soil enabling the plant to take up more phosphate, rather than an action in the plant enabling it to use phosphate better, as was previously supposed.

Elements needed only in small amounts. The necessity of boron and of manganese in small amounts has already been demonstrated in earlier reports. Recently, R. V. Allison, in Florida, obtained striking crop increases by the use of copper sulphate on certain Florida " muck " soils, which apparently resemble some of our fen and peat soils. Dr. Brenchley has made trials on a number of crops on these soils, but found no response to copper sulphate : there seems, therefore, no likelihood of it proving useful here.

SOIL CULTIVATION.

The experiments on soil cultivation follow three general lines. Measurements are taken in the field of the draught or drawbar pull of the implement and of the effect it has had on the soil. Laboratory experiments are made to study the physical properties of the soil, including stickiness, tilth, its relations to water, air and temperature, and so to explain the field observations. Finally, field experiments are made to test other and simpler methods of achieving the same results as present-day cultivation methods.

Earlier work had shown that heavy dressings of chalk, such as were formerly given in Hertfordshire, markedly reduced the drawbar pull necessary to get a plough through the soil. The smaller dressings now customary have been tried during the past three years : five tons per acre of finely divided chalk and 30 cwt. per acre burnt lime ; but at Rothamsted neither caused any appreciable reduction in drawbar pull, though another property was affected, as shown later.

Among the attempts to simplify cultivation, the rotary cultivator is one of the more promising : it achieves in one operation what the usual implements do in two or three, and thus offers the possibility of reduction in cost. It proved better in 1926 than either the ordinary ridge or flat cultivation for swedes during the first part of their growth, but not afterwards ; the rotary cultivated plots then "capped " or hardened considerably ; ordinary cultivation methods were used for the succeeding barley in 1927, but the effect of the 1926 rotary cultivation was still visible and was entirely beneficial—a residual effect that was not expected and cannot yet be explained. The values for yields were :—

Barley, 1927.	Former rotary-Cultivation.	Horse Cultivated.	Horse Ploughed.	General Mean.	Standard Error.
Grain.					
Per cent. ...	117.0	91.0	92.0	100.0	4.89
Bushels ...	27.8	21.6	21.9	23.8	1.16
Straw.					
Per cent. ...	111.1	95.3	93.6	100.0	2.35
Bushels ...	21.7	18.6	18.3	19.5	0.46

In 1928, swedes were again grown, but on different land: this time, however, rotary cultivation caused no "capping" and no difference in growth, as compared with ordinary cultivation. This variation of result with season was expected, and is being studied: the bad effect in the summer and autumn of 1926 is not easily understood. The rotary cultivator produced in each year as nearly as can be measured the same degree of disintegration of the soil as ordinary cultivation, except when the soil was in an unkind or difficult condition for cultivation: in this case rotary cultivation was less effective than the ridging plough. The experiments further showed the value of the ridging plough in breaking up an unkindly soil.

The purposes of cultivation are threefold: (1) the formation of tilth, (2) the conservation of moisture, (3) the suppression of weeds. It is not agreed how closely (2) and (3) are linked, but it is certain that weed suppression is an important function, and this has been studied by Dr. Brenchley and Miss Warington on the permanent plots of both Woburn and Rothamsted. One of the chief factors is the time the weed seeds can live in the ground. Cultivation encourages the germination of Black bent (*Alopecurus agrestis*). Poppy (chiefly *Papaver rhoeas*), however, survives much longer in the soil: its seeds are still germinating in a sample of Broadbalk soil taken in 1925 and continuously cultivated ever since in a glasshouse, where contamination is reduced to a minimum. The seedlings are removed as they appear, so that no fresh seeds reach the soil, yet already the number of plants appearing has been at the rate of 33 millions per acre on the plot receiving no nitrogen and up to 205 millions per acre on one of the completely manured plots.

The principles of cultivation: the meaning of tilth.

A great deal about cultivation must remain obscure until we know what it does to the soil and how it does it. The science of cultivation is only in its infancy, and is far behind the science of manuring; advice can be given only empirically and tentatively. The subject is, however, steadily being developed by Dr. Keen and his staff, Dr. Schofield, Mr. Scott-Blair and Mr. Cashen. The mechanical principles involve the movements of layers of soil against and over each other and against the metal surface of the implement. Special methods have been designed for working these out: measurements are made of the Static Rigidity, *i.e.*, the energy required to cause a soil paste just to flow; and of the viscosity (more strictly pseudo-viscosity) of the paste once it has begun to flow. The measurements of static rigidity are closely related to the observed Draw Bar Pull, but represent only one group of the factors involved, *e.g.*, a dressing of one ton per acre of slaked lime reduces the static rigidity, but not the dynamometer values.

"Single value" soil constants. The only method at present available for the physical specification of a soil is mechanical analysis, but this is tedious, and the results have only a qualitative value. Attempts have been made from time to time to develop other simple measurements of some single property (or group of properties) easily expressed by a figure, and thus serving as "single-value" soil constants. The subject has now been

https://doi.org/10.23637/ERADOC-1-85

re-opened at Rothamsted. The " sticky point " (*i.e.*, the moisture content at which a plastic mass of soil and water is just about to become sticky) is promising. It is closely correlated with the loss on ignition which may be taken as an approximate measure of the amount of the organic and the inorganic colloids : it is not, however, correlated with the percentage of clay. The amount of moisture in air dry soil is correlated with the percentage of clay, but not with the loss on ignition, *i.e.*, not with the total colloids : this moisture is therefore presumably held in the minute interstices between the small particles. On the other hand, the clay and the sticky point, and the ignition loss and the air dry moisture content, are significantly correlated. These results indicate two ways in which the water is held in the soil. The organic and the inorganic colloids control the sticky point, while the minute interstices between the small particles control the air dry moisture content. Confirmation has been obtained by repeating the measurements after treating the soil with hydrogen peroxide to remove the non-structural organic matter. The two values are therefore of help as a means of soil specification, and an extended co-operative comparison of them for many different soil types has been agreed to by the International Society of Soil Science. This work will be controlled from Rothamsted.

THE CONSTITUENTS OF THE SOIL.

The Organic Matter.

For some years past the chemical changes occurring during the decomposition of plant residues in the soil, and especially those concerned in the formation of humus, have been studied by Mr. H. J. Page and his staff, G. V. Jacks, C. E. Marshall, C. W. B. Arnold and others.

Lignin is the main, though not the only source of humus, but the plant residues apparently humify as a whole.

Humus is very complex in composition, and its effects in the soil are not yet fully known. There is an important difference between the humus of the soil and that of leaf mould and peat : while all three kinds of humus yield up ferric iron after hydrolysis with acid in boiling solution, soil humus gives ferrous iron also.

Now iron may play an important part in the oxidation processes in the soil : for example, the artificial production of humic acid from lignin by atmospheric oxidation in strongly alkaline solution takes place only in the presence of organically combined iron.

The clay and the reaction of the soil.

The reaction of the soil is closely associated with the amount of the bases, particularly calcium, that can be replaced by other bases when the soil is mixed with a salt solution. Much work is being done on the amounts of these replaceable bases in the Woburn soils.

The exchangeable calcium is greatly reduced by sulphate of ammonia, and slightly increased by nitrate of soda, superphosphate and farmyard manure. The exchangeable potassium is very low : it is hardly affected by nitrate of soda or sulphate of ammonia in spite of the fact that this reduces the calcium, but

https://doi.org/10.23637/ERADOC-1-85

it is much increased by farmyard manure. A method is badly needed for estimating the extent to which the soil is saturated with bases, or, alternatively, the extent to which the bases have been replaced by acid hydrogen: attempts are being made to solve this problem by mixing the soil with excess of calcium carbonate and extracting with sodium chloride.

The most widely used and most convenient way of measuring the reaction of the soil is the quinhydrone electrometric method. Miss Heintze and Dr. Crowther used it for a series of Gold Coast soils and obtained clear and definite results at least one-third of which subsequently proved to be quite erroneous.

The trouble was traced to the manganese dioxide present in certain soils in a form which reacts with the quinhydrone producing a base and a corresponding reduction in acidity. Similar errors have been found in English soils and methods of detecting and avoiding them are being worked out.

SOIL MICROBIOLOGY.

The investigations in soil microbiology fall into two main divisions: (1) the study of the micro-organisms living in the soil, their kinds, numbers, mode of life, their various activities and their relation to one another.

(2) A detailed study of soil micro-organisms directly affecting plants: the nodule organisms of the leguminosæ, organisms parasitic on plants and producing diseases.

The chief groups of soil micro-organisms are: bacteria, fungi, including actinomycetes, algæ, protozoa and nematodes: all are studied at Rothamsted except the nematodes, which are left to the Institute of Helminthology, St. Albans, though it is hoped to effect some co-operation with this body as the work is now beginning to suffer through so artificial a restriction.

All the organisms, except some of the protozoa, feed on the organic matter in the soil, some of them also ferment part of it: in either case, they decompose it, producing humus, nitrates, phosphates and compounds of calcium, potassium and other elements of great importance in soil fertility. Soil micro-organisms are, to a large extent, the producers of soil fertility, though they also reduce it by assimilating to themselves nitrates and phosphates that would otherwise serve for plants. It is this close connection with soil fertility that justifies the extended study made of them at Rothamsted.

Broadly speaking, fungi predominate in acid soils and bacteria in neutral soils, and of the substances they decompose fungi assimilate more, build up more protoplasm and retain more nitrogen than do bacteria: they are less economical as plant food producers because bacteria convert more of the organic matter into carbon dioxide, water and ammonia. For this reason less of the nitrogen can be nitrified in an acid than in a neutral soil.

There is considerable difficulty about estimating the numbers of fungi and studying their activity: Dr. Brierley has shown how to obtain comparable data under strictly controlled conditions, but the results have no absolute value and the higher figures are not intrinsically more probable than the lower ones. More can be done with the bacteria. Their numbers can now be estimated by Messrs. Thornton and Gray's direct method much more rapidly and completely than before: when the counts were first made at Rothamsted by the old plating method, a usual estimate (known, however, to be very incomplete) was 10-30 millions per gram, and the experiment took ten days to complete: now the estimate (which, however, includes dead organisms) is 1,000-5,000 million per gram, and the experiment takes only two hours. The numbers are related to those of the protozoa; they are high when the protozoan numbers are low, and low when the protozoan numbers are high: this is because the protozoa feed on the bacteria. The "nutritive values" of the various bacteria differ; for one of the most "nutritious" an increase of 3,400 amœbæ (*Hartmanella hyalina*) per gram involved the disappearance of 1,444,000 bacteria, *i.e.*, something over 400 bacteria were consumed to produce one amœba. The effect of the protozoa on the decomposition of plant residues by bacteria and fungi is being studied: it apparently differs according as the action is a fermentation or a consumption for food.

One of the most far-reaching factors in the situation is that micro-organisms need adequate supplies of nitrogen and of phosphate and can decompose carbohydrate only in proportion to the amounts of these substances present. This is the fundamental principle underlying the making of farmyard manure. Straw is put under the animals as litter and, being mingled with their excretions, is decomposed by micro-organisms to form the familiar black, sticky substance known as humus. In doing so, however, the organisms assimilate some of the ammonia of the excretions, converting it into their body tissue, in which form it is insoluble and some of it is not easily nitrifiable. Thus the nitrogen in farmyard manure is of three kinds: the original complex nitrogen compounds of the straw and solid excreta; simple and easily nitrifiable compounds (urea and ammonia) of the liquid excreta; and complex nitrogen compounds of the bodies of the micro-organisms derived from these simple compounds. Not all of this nitrogen is readily nitrified; Dr. Jensen, in the Bacteriological Department, shows that only the excess of nitrogen over a certain amount is quickly nitrifiable, the proportion of non-nitrifiable and therefore less useful nitrogen depending on the amount of carbon present and also on the reaction of the soil. In a neutral or alkaline soil, for every 20-25 parts of carbon, one part of nitrogen nitrifies only slowly; for an acid soil the figures are one part nitrogen for every 13-18 parts of carbon. This accords with the observation that farmyard manure is much more effective in a neutral than in an acid soil, and it explains why farmyard manure and other plant residues containing less than about 1.5 per cent. nitrogen in the dry matter supply very little nitrate and are therefore of little help in soil fertility, thus emphasising the very serious nature of the losses when the soluble nitrogen compounds in farmyard manure are leached out by rain.

Artificial farmyard manure. This fuller knowledge of the mechanism of the decomposition of cellulosic materials is not only useful in the management of farmyard manure: it forms the basis of a method of producing an artificial farmyard manure, closely resembling the ordinary material. Straw need not be put under the animals for the purpose of effecting its decomposition; the organisms work equally well if it is wetted with a solution of a nitrogen compound such as an ammonium salt or cyanamide containing sufficient phosphate. The important factors are the presence of sufficient nitrogen (0.75 parts to each 100 parts of ripe cellulosic material) and of pentosans at least equal in amount to the lignin; when these are correctly adjusted, the organisms rot down the material and give a black humus manure. The method has proved of value where insufficient live stock is kept to make enough manure, as in market gardens, plantations, and some special types of arable farming: it is now used extensively in many countries, and new waste materials are continuously being tested. Cocoanut husk has this year been successfully converted into a manure containing 0.4 per cent. nitrogen, and little, if at all, inferior to farmyard manure. Rye straw presents special difficulties, because it cannot readily be wetted: means are being tested to overcome this.

Another practical application is, perhaps, somewhat unexpected. The chain of processes beginning with plant residues and ending up with carbon dioxide and ammonia is the basis of the purification of sewage and other effluents. Sewage has on several occasions been the subject of investigation at Rothamsted, the purpose being to obtain from it, if possible, a useful manure. For the moment this investigation is suspended pending the successful drying of the very promising sludge finally obtained. During the past two years, the same problem has appeared under another form. The effluents from sugar factories have usually been run direct into rivers where they have caused considerable nuisance and damage to fish. At the request of the Department of Scientific and Industrial Research, an investigation was begun to discover some suitable and effective methods of treatment. The work is being done partly at Rothamsted and partly at the sugar factory at Colwick, Nottingham; the problem is to remove the waste roots and tails of the beets and to convert the plant juices contained in the effluent into carbon dioxide, water and ammonia as rapidly and economically as possible. The experience gained at Rothamsted with this particular decomposition enabled Messrs. Cutler and Richards to start several lines of experiment as a result of which a microbiological process was devised that gives almost complete purification. The effluent is run through a clinker filter on which a film of organisms develops, including bacteria, protozoa, yeast-like bodies and, probably, other fungi: some of the bacteria decompose the sugar rapidly to produce acids and gas; others do not decompose sugar, but presumably attack the products formed by the first. Nearly 750 different strains of bacteria have been isolated and studied, and the remaining population of the film is also being investigated. The film is well suited for the development of protozoa—better, indeed, than the ordinary nutrient agar of the laboratory—but it can also be attacked by the larvæ of the "sewage fly" (*Collembola Acheureutes*).

The problem now is to cheapen the process and to discover what degree of purification is in fact necessary, for every per cent. of purification beyond a certain point adds to the expense.

https://doi.org/10.23637/ERADOC-1-85

Organisms directly affecting plants : Lucerne and its nodule organism.

In the Bacteriological Department, Mr. Thornton has continued his studies of the relations of the nodule organism to the lucerne plant. The organisms enter the root hairs, they travel along into the root, then multiply and cause the cells to multiply and form a nodule. Very few nodules are formed so long as the seedling leaves alone are present : they suddenly appear when the true leaves emerge. Apparently the opening of the leaf is accompanied by the extrusion from the root of some substance which stimulates the bacteria and enables them to infect the root hairs. This substance can be found in the medium surrounding the root : a water extract of sand in which lucerne seedlings have just formed their true leaves, stimulates the growth of the organism in artificial cultures more than a water extract made just before the leaves open. Attempts are now being made to discover the nature of this substance.

Earlier experiments of Mr. Thornton and Miss Brenchley showed that the co-operation between plant and organism remained effective only so long as connecting channels were made between the nodule and the circulating system of the plant ; these are needed to convey carbohydrate from the plant to feed the organisms and to remove the nitrogen compounds made by the organisms. It is still a mystery how the plant comes to make the connection as soon as the nodule is ready, and the mystery is deepened by the discovery that a minute trace of boron is essential : unless this is present, no connection is made, and the nodule bacteria can neither pass on to the plant the nitrogen compounds they have prepared, nor draw their necessary carbohydrates from the plant ; they therefore decompose the cells of the plant root, thus becoming harmful. Mr. Thornton now shows that the same result is obtained if the carbohydrate supply to the nodule is cut off by keeping the plants in the dark.

Soil algæ. Dr. Bristol Roach has collected and summarised her work on the soil algæ. The mode of life of these organisms differs according as they are on the surface exposed to light or below the surface in darkness. When they occur on the surface they function like other green plants, assimilating nitrate, phosphate and other plant foods from the soil and carbon dioxide from the air, which by photosynthesis they transform into organic matter rich in potential energy. All this is added to the soil when they die. When they are carried down below the surface they do not necessarily die : they can change their mode of life, become saprophytic and feed on some of the organic matter already existing in the soil, apparently the soluble or easily decomposable organic compounds : they can, for example, secrete an enzyme that liquifies gelatine. There is no evidence of any excess of decomposition products that could contribute to plant nutrition, and the general functions of the algæ in relation to soil fertility seem to be :—

(1) they assimilate nitrate and phosphate from the soil, converting them into insoluble nitrogen and phosphorus compounds ;

(2) when living at the surface of the soil they increase the supply of easily decomposable organic matter rich in energy;

(3) when living below the surface, they assimilate soluble or easily decomposable organic matter in addition to the nitrate and other nutrients referred to above;

(4) they can thus be regarded as agents for increasing the stock of energy material in the soil and for immobilising soluble nutrients and organic compounds, converting them into an insoluble but readily decomposable form.

DISEASE ORGANISMS AND PESTS.

Disease in plants may result from several causes: from insufficiency or excess of some essential requirement, from the attack of a parasite, either fungus, bacterium or insect, or from a virus, a name given to some obscure agent, the nature of which is not understood. For the present, the first group, the so-called physiological diseases, are not studied although numerous instances occur on our plots where deficiencies or excess of the various nutrients have become intensified by long continuance on the same land of an unaltered scheme of cropping or manuring.

One of the difficulties of the work is that some of the organisms, especially, perhaps among the fungi and bacteria, may not be fixed in their relationship to the plant or, indeed, in their own characters. Under constant or changed conditions a species may assume a different form, sometimes with different properties and, indeed, may be mistaken for a new or another species; further, while harmful in some conditions, it may be relatively harmless in others.

Dr. Brierley is studying the nature and the extent of the changes that can be induced in the common parasitic fungus *Botrytis cinerea*, by alteration in its food and other environmental factors. He finds that some of these changes are purely temporary, disappearing at once when the old conditions are restored; some are more permanent, lasting for a number of generations and showing gradual reversion whilst still others are apparently quite permanent. Further work is necessary to ascertain the consequence of these important results and their relation to the incidence of disease in crop plants. Further changes in conditions may influence greatly the effectiveness of a fungus in attacking plants.

Dr. and Mrs. Brierley find that certain species of Fusarium which cause root disease in wheat behave differently in pure culture and in soil: in pure culture the development of the fungi shows a marked relation with temperature, being slow at 13° C., more rapid at higher temperatures, but ceasing above 30° C. In soil, however, no difference could be observed, the amount of disease produced at 30° C. being apparently just as much as at lower temperatures.

These and other observations show the necessity for close study of the conditions in which a disease organism is acting, and they have led some to adopt the view that studies of crop diseases can be made only in the actual district where the disease occurs.

https://doi.org/10.23637/ERADOC-1-85

With improvements in electrical equipment it has become possible to maintain experimental conditions constant for long periods and, in consequence, to reproduce in the laboratory specified conditions, especially those of temperature and moisture.

In order to see how far the studying of a tropical disease is useful in an English laboratory, an investigation is being made by Mr. Stoughton of the "angular leaf spot" type of the "Black arm" disease of cotton caused by *Bacterium malvacearum*.

Cotton is grown in glasshouses and develops ripe bolls with good lint and healthy seed. Infection experiments under controlled atmospheric conditions are carried out on these plants. Cotton is also grown from seed in a series of special chambers in which light, air and soil conditions are controlled, and the natural and artificial infection of young plants is examined in relation particularly to air and soil temperature, and air moisture. The results are compared with those obtained by Major Archibald and Mr. Massey in the Sudan. Already it appears that this co-operation of tropical and British workers is advantageous: it is certainly economical to do as much as possible of the pure investigation work at home, reducing labour for the tropical worker and allowing him to devote himself wholly to those problems which can be solved only on the spot. The funds for this investigation have been provided by the Empire Marketing Board.

Wart disease of Potatoes.

In spite of much investigation, no field method has yet been discovered for treating the soil so as to kill all sporangia of the organism (*Synchytrium endobioticum*) causing this disease. Treatment with sulphur has been effective on occasion, but not always: apparently, therefore, the active agent is not the sulphur itself, but some substance formed from it. The acidity produced by the sulphur accounts for part of the effect: the disease is almost completely suppressed when the soil acidity is raised to pH 3.4. But this is not the whole explanation: suppression sometimes occurs at lower acidity. Experiments by W. A. Roach and Miss Glynne suggest that thiosulphuric acid (a possible product of oxidation of sulphur in the soil) has a special toxic effect over and above that due to the hydrogen ion concentration. This investigation will be followed up when suitable methods can be found.

Miss Martin has confirmed the fact that the fungus is not confined to potatoes, but can attack various other solanaceous plants, and has discovered a number of additional hosts.

Virus diseases of plants.

These diseases are spreading and they have caused so much loss at home and in the Empire that the Empire Marketing Board has made a special grant for five years to allow of the appointment of an entomologist, a cytologist and a plant physiologist to work in collaboration with Dr. Henderson Smith, and to provide special equipment and the necessary, but costly, insect-proof glasshouses in which the investigations may be carried out.

Nothing is known of the nature of virus except that it is not a recognisable organism; the name is entirely non-committal and is used to denote the agent causing these particular diseases. Virus is often contained in extracted plant juice, and certain of its properties have been studied, *e.g.*, its reaction towards alcohol, temperature and ageing, but the problem is rendered difficult by the circumstance that a virus disease apparently may not in all cases be a single disease, but a complex caused by two or more viruses closely related, but differing in stability or other property. A virus may not be specific to one plant: the foliage of potatoes suffering from mosaic will infect tomato plants, though that of healthy potato plants will not. Other solanaceous hosts may also be infected with the virus of potato mosaic, but not the non-solanaceous hosts tested. Two viruses mixed may give a disease different from that caused by either: the aucuba mosaic of tomato *plus* potato mosaic causes a Tomato Streak Disease; Miss Jarrett has shown that the mottled type of Streak Disease *plus* potato mosaic also gives a Streak Disease.

These investigations are further complicated by the great difficulty of getting healthy plants for experiments: plants may have a virus disease, but show no symptoms. With certain viruses, intracellular bodies have been found in the cells of diseased plants, but their nature and significance are still uncertain.

ENTOMOLOGY.

In the Entomology Department the main work has been the study of certain insect pests and possible methods for their control. In nature, control is largely effected by parasites, and this fact has led to the investigation of the extent to which some of our insect pests are parasitised in the field. Special attention has been devoted to the parasites of Frit fly and of certain injurious Gall Midges with reference to the species involved and their economic status.

Preliminary trials by Dr. Davidson on the effects of certain substances, absorbed by the roots of plants, on sap-sucking insects have led to further exploration of its possibilities. In conjunction with Mr. Henson, Dr. Davidson has shown that broad beans watered with suitable concentrations of pyridene could be rapidly freed from aphis attack. Aphides infesting such plants failed to multiply to any appreciable extent and rapidly died. On control plants without pyridene, infestation was constant and multiplication rapid. The effects of pyridene on the plants, in the lowest effective concentrations, was noticeable in a reduction in the dry weights of those plants, but the subject is one requiring much fuller investigation. Dr. Barnes has studied the life-histories and parasites of injurious gall-midges affecting osier willows, meadow foxtail and wheat, with a view to discovering possible means of their control. In the case of species infesting osier willows, evidence of significant varietal differences in susceptibility to attack is receiving attention, both under experimental and field conditions.

Grants from the Empire Marketing Board for the purpose of controlling noxious weeds by insects, have led to work being undertaken on this subject in conjunction with the New Zealand Government and the Cawthron Institute at Nelson. The bramble is a serious menace in New Zealand, and the possibility of controlling it has been attempted by the shipment of consignments of the beetle (*Corœbus rubi*) from the South of France to that country. Gorse is another pest plant, and very large numbers of the weevil *Apion ulicis*, have been sent to control it. Ragwort is a third pest, and many thousand pupæ and eggs of the moth *Tyria jacobœ* have been shipped to New Zealand. Before being sent out, the insects are tested at Rothamsted on all likely plants growing under British conditions; in New Zealand they are further tested before liberation, so that the possibility of danger is reduced to a minimum.

This work has now been carried beyond the research stage, and methods have been evolved for the regular transmission to New Zealand of the insects concerned. The scheme in future is to be centralised and further developed under the special facilities available at the laboratory of the Imperial Bureau of Entomology at Farnham Royal, and the co-operation of Rothamsted will consequently terminate.

Dr. Handschin has devised apparatus for studying the movements of insects in the soil in response to changes of temperature and humidity, with greater refinement than was hitherto possible. His work on the subject is being continued on his return to Basle, and will be further elaborated before any publication of the results is made.

INSECTICIDES.

The investigations carried out under the direction of Dr. F. Tattersfield in collaboration first with Mr. C. T. Gimingham and now with Dr. Hobson, have, for their general purpose, the discovery of new and improved substances for killing the insect pests of fruit and other trees. Much of the work is done in the laboratory and insectary, but as soon as a promising substance is found it is tested in the open on growing trees, so as to find out how far it would be effective in practice.

Insecticides fall into two great groups : those used in winter against the eggs, which are generally laid by the parent on the tree to be attacked, and those used in summer against the young animal as soon as possible after it hatches out. The eggs, being more resistant than the young animal, need a stronger poison : fortunately, the tree is then resting and is devoid of leaves so that it can tolerate substances that would injure it later on : hence winter washes must and can, without harm, be fairly potent.

The older winter washes were made up of caustic soda, or lime and sulphur; more recently tar distillates have come into use and these are now standardised sufficiently well for practical purposes. Being by-products they are likely to change if the method of treating coal should alter. Other winter washes are sought at Rothamsted, the work being done on systematic and fundamental lines, finding out what chemical groups are most

https://doi.org/10.23637/ERADOC-1-85

toxic to insect eggs and then combining these so as to build up a suitable insecticide. Of the substances tested, a dinitrocresol has proved highly effective, and is easy to make on a large scale: it is so potent that ½ to 1 ounce makes sufficient wash for a large standard tree, and few, if any, of the eggs, escape. This high effectiveness is a great advantage where transport is a consideration. The only complaint made by the practical men who tested it is, that when it gets on the hands and clothing, it stains them yellow.

The summer washes, being used against young living insects, need not be so penetrating in action, but they must be harmless to the young leaves. Two kinds are in use: stomach poisons and contact insecticides. The stomach poisons are used against insects or caterpillars that eat the leaves: lead arsenate is popular among growers, but is open to various objections; attempts are therefore being made at Rothamsted to find something different but equally good. Some of the silico-fluorides are proving valuable; they also are easily made on the large scale, and are free from the stigma attaching to arsenic. The contact insecticides kill by touching; how, exactly, is not known; they are used against sucking insects such as green flies and capsid bugs. Nicotine is most commonly used: it is made only by few firms, and always from one substance, tobacco; alternative substances are, therefore, highly desirable. The necessity for high toxicity to the insect and harmlessness to the leaf rules out many possibilities, the desirability for harmlessness to human beings further narrows down the choice, and has restricted it up to the present to certain paraffins and to vegetable poisons, the latter being the more convenient. Much work has been done on these at Rothamsted. The method is to try the parts of the poisonous plant on the insect to find where the poison is, then to isolate it and study it in detail, finding its chemical nature, methods of detection and estimation. Four plants are especially promising: Derris from Malay, which contains its poison in its roots; Tephrosia from tropical Africa; a climber, Haiari (both white and black varieties), from the forests of British Guiana; and Pyrethrum, the only one which grows in temperate regions. All these could be cultivated in their respective climates, and the chemical work is so far advanced that the chemist can advise the grower and breeder whether he is maintaining, increasing, or lowering the toxic properties of the plant by his treatment. Remembering the remarkable improvement following the chemical control of the sugar beet crop, there seems great scope for improving these insecticidal plants. The most poisonous of the principles when extracted from the plant prove to be extraordinarily deadly to certain insects: a spray containing only about one ounce of the pure poison from pyrethrum flowers dissolved in a ton of water is fatal. Fortunately, it is not harmful to human beings. The Derris compound called Tubatoxin is only slightly less potent, and it is also highly effective against many parasites.

At present, the poisonous substances are most easily obtainable by growing the plant, and they need not even be extracted except where transport is important. The cultivation of these plants bids fair to become a useful industry, pyrethrum at home, and the others in the tropics; this part of the problem is being studied in close co-operation with the Ministry of Agriculture Plant Pathology laboratory at Harpenden.

BEE RESEARCH.

The prevalence of acarine disease has hitherto considerably hampered work, but the Ministry of Agriculture has now agreed to remove the restriction on the programme of work which had previously cut out the study of bee diseases. Cane sugar has been compared with beet sugar as winter food, but no difference could be detected. Further tests were made of the respective merits of the "warm" and "cold" way of arranging the frames in the hives, and the data are now being examined in the Statistical Department. The programme of bee research is drawn up by a Committee of Bee Experts who, from time to time, meet to discuss problems of importance to bee keepers.

SCIENTIFIC PAPERS

Published 1927 and 1928 and in the Press.

I.—CROPS, PLANT GROWTH AND FERTILISER INVESTIGATION.

(Botanical, Chemical and Statistical Departments.)

I. E. J. Russell. "*The Institute of Brewing Research Scheme: Fourth Report on the Experiments on the Influence of Soil, Season and Manuring on the Quality and Growth of Barley, 1925.*" Journal of the Institute of Brewing, 1927. Vol. XXXIII. (Vol. XXIV., New Series), pp. 104-110.

II. E. J. Russell. "*The Institute of Brewing Research Scheme: Fifth Report on the Experiments on the Influence of Soil, Season and Manuring on the Quality and Growth of Barley, 1926.*" Journal of the Institute of Brewing, 1928. Vol. XXXIV. (Vol. XXV., New Series), pp. 307-320.

III. E. J. Russell. "*The Barley Experiments of the Institute's Research Scheme.*" Journal of the Institute of Brewing, 1928. Vol. XXXIV. (Vol. XXV., New Series), pp. 436-446.
See also pp. 26-30 of this Report.

IV. L. R. Bishop. "*Composition and Quantitative Estimation of Barley Proteins I.*" Journal of the Institute of Brewing, 1928. Vol. XXXIV., pp. 101-118.

Methods have been devised and tested for the quantitative estimation of the amounts of the separate proteins in barley grain. Albumin, globulin and protein breakdown products are extracted by 5 per cent. potassium sulphate solution, 70 per cent. alcohol at 81° C. is used to extract hordein from the residue; the remaining nitrogen probably represents glutelin nitrogen.

These methods have been applied to samples of Plumage-Archer barley grown under varied conditions of season, soil and manuring. These differing conditions influenced the total nitrogen of the grain but not the regular relation shown between the amounts of the separate constituents and the total nitrogen. In the samples the total nitrogen varied from 1.2 per cent. to 2.3 per cent. and (*a*) the percentage of glutelin nitrogen remained constant at 36 per cent. of the total nitrogen, (*b*) the percentage of hordein nitrogen increased regularly with increasing total nitrogen from 28 per cent. with 1.2 per cent. total nitrogen to 40 per cent. with 2.3 per cent. total nitrogen, (*c*) the percentage of salt-soluble nitrogen fell correspondingly from 36 per cent. to 24 per cent. as the total nitrogen increased from 1.2 per cent. to 2.3 per cent.

There appears to be a balance between the amounts of the various proteins, which adjusts itself according to the amount of total nitrogen present. For these samples therefore the total nitrogen is a good measure of the amounts of the individual proteins and varying " quality " of different samples of the same total nitrogen content is not due to differences in the amounts of the individual proteins.

V. L. R. Bishop. *" Composition and Quantitative Estimation of Barley Proteins II."* Journal of the Institute of Brewing, 1929. Vol. XXXV., pp. 316-322.

The methods for the quantitative estimation of the proteins of barley grain are extended. A detailed fractionation of the salt-soluble substances is worked out. In this extract albumin, globulin, proteose, and peptone nitrogen are estimated as well as nitrogen in the form of simple compounds such as amino-acids (" non-protein " nitrogen). It is concluded that hordein persists from the barley to malt and that the methods found suitable for barley can be applied also to malt.

The importance of fineness and evenness of grinding is shown.

VI. L. R. Bishop. *" The Changes undergone by the Nitrogenous Constituents of Barley during Malting."* Journal of the Institute of Brewing, 1929. Vol. XXXV., pp. 323-338.

As soon as active breakdown commences after steeping, the two insoluble proteins of the endosperm, hordein and glutelin, are broken down at about the same rate to give salt-soluble products chiefly non-protein nitrogen. Then the rate of disappearance of glutelin falls off. Later, the rate of disappearance of hordein becomes very small and the amount of glutelin may increase slightly. At this stage it is kilned.

The falling off in rate of disappearance of glutelin and the suggestion of a subsequent increase point to a resynthesis of this protein in the embryo. The falling off in rate of disappearance of hordein may similarly be accounted for by resynthesis in embryo.

The changes in the nitrogen compounds on the kiln when making pale malts are very slight.

Changes within limits of the amount of water supplied or the length of time on the malting floor produced but little effect on the amounts of different nitrogen compounds in the final malt, owing to the establishment of a balance between breakdown in the endosperm and resynthesis in the embryo.

VII. F. E. Day. *" Small Scale Brewing in the Laboratory."* Journal of the Institute of Brewing, 1928. Vol. XXXIV., pp. 570-573.

A technique has been devised for obtaining a reasonable top yeast crop and beer of normal flavour in the small scale brewings in the Laboratory. Filtration is avoided and brewery conditions are imitated as closely as possible by conducting the fermentation in Thermos flasks. The method can be applied to the comparison of small samples of malts and the examination of hops.

VIII. W. E. Brenchley. "*The Phosphate Requirement of Barley at Different Periods of Growth.*" Annals of Botany, 1929. Vol. XLIII., pp. 89-110.

Experiments have been made in water cultures to test the effect of depriving barley plants of phosphorus after varying initial periods during which it had been supplied, and of supplying phosphorus after initial periods of deprivation.

The provision of phosphate for the first six weeks or longer permitted normal growth to be made, as was shown by the number of tillers, ears, and grains produced, the average number of grains per ear, and the dry weights. With shorter initial periods of phosphate supply growth was seriously depressed in all these respects. If phosphate was withheld for the first four weeks, tiller production was not affected, but no ears were produced. With longer initial deprivation, growth was steadily depressed in all respects, and the type of growth gradually changed from a bushy, succulent character to a thin, lanky, untillered plant bearing the travesty of an ear.

The amount of phosphate absorbed by the plant increased steadily in more or less direct proportion to the length of time phosphate was given at the beginning of growth, but sufficient was taken up in the first six weeks to enable the plant to make its maximum dry weight. The percentage of phosphate in dry matter rapidly increased from this time onwards. The absence of phosphate supply up to the first six weeks of growth caused an extremely rapid drop in the amount of phosphate ultimately taken up by the plant, after which a more gradual decrease occurred with lengthening periods of phosphate deprivation. The probable importance of the presence or absence of phosphorus at the time tillering begins is indicated by reference to further experiments in which phosphate was supplied and withheld for alternate fortnights during growth.

IX. R. A. Fisher. "*A Preliminary Note on the Effect of Sodium Silicate in Increasing the Yield of Barley.*" Journal of Agricultural Science, 1929. Vol. XIX., pp. 132-139.

The addition of sodium silicate has been found to increase the yield of barley to a considerable extent, this effect being most marked when no superphosphate is added.

The phosphatic content of the ash is not greatly increased in the grain, and is diminished in one case in the straw; the conclusion from this observation that the silicate does not act by releasing soil phosphates, but as a plant stimulus, overlooks the fact that the addition of silica to the ash naturally reduces the percentage of other constituents, and should be discounted.

The phosphate removed annually in the crop is greatly increased on the plots receiving silicate, even when this removal has continued for many years without replacement.

That additional phosphate is actually made available to the crop on the plots receiving silicate is shown by the increase in the proportion of phosphate in the dry weight of the crop, which appears on all the plots, and at all periods.

This increase is quantitatively sufficient to account for the increased yield in grain and straw, without postulating the aid of any stimulus to plant growth.

X. T. EDEN AND R. A. FISHER. "*Studies in Crop Variation, IV. The Experimental Determination of the Value of Top Dressings with Cereals.*" Journal of Agricultural Science, 1927. Vol. XVII., pp. 548-567.

A simple account of a top dressing experiment carried out at Rothamsted in 1926, with especial reference to the design of such experiments in general, to the statistical analysis of the data, and to the precision attained. The experiment was of 96 plots of winter oats and designed to test with precision the return from top dressings applied early or late, in single or double quantities, and using sulphate or muriate of ammonia. All possible combinations of these conditions were used, the whole having eight-fold replication. The results possessed a higher level of precision than on any previously attained in conditions which allow of a valid estimate of error, the standard error of each comparison being only 1.4 per cent. It is, then, of an order which allows discussion of the monetary return to the industrial farmer in relation to the cost of manure and labour. The experiment is one of a programme of research into top dressings, which it is hoped can be maintained at the same level of precision.

XI. BHAI BALMUKAND. *Studies in Crop Variation, V.* "*The Relation between Yield and Soil Nutrients.*" Journal of Agricultural Science, 1928. Vol. XVIII., pp. 602-627.

It is shown (*a*) that it is possible to fit Maskell's Resistance formula (in which the reciprocal of the yield is expressed as the sum of terms each dependent on a specific manurial factor) to experimental data involving the simultaneous variation of two numerical factors by a sufficiently rapid process of approximation, (*b*) that in every case discussed the formula fits the facts within the limits of experimental error estimated from the experiments themselves although formulæ of other types fail strikingly to do so, (*c*) that the parameters appropriate to each nutrient are therefore independent of other conditions and are capable of direct physical interpretation. The interpretation suggested supplies a direct measure of the quantity of each soil nutrient actually available to the plant, and of its specific importance in determining yield.

II.—STATISTICAL METHODS AND RESULTS.

(Statistical Department.)

XII. R. A. FISHER. "*The General Sampling Distribution of the Multiple Correlation Coefficient.*" Proceedings of the Royal Society (A), 1928. Vol. 121, pp. 654-673.

By an appropriate linear transformation of the independent variates it may be shown that the sampling distribution of the multiple correlation coefficient does not depend on the whole matrix of correlations between these variates, but solely upon the multiple correlation in the population sampled.

The actual distribution (A) may then be easily obtained by similar methods to those by which the distribution of the simple correlation coefficient has been obtained.

The frequency function involves a hypergeometric function of P^2R^2 which is a rational function when n_1 and n_2 are both even, algebraic when n_2 only is even, and reducible to circular functions when n_1 and n_2 are both odd.

The case of large samples yields a series of distributions (B) of great interest, involving Bessel functions, which connect the X^2 distributions with the Gaussian, and are intimately related to a double Poisson summation. Owing to the practical importance of this limiting form, a table of its 5 per cent. points is given up to seven independent variates.

When n_2 is even, the probability integral of the general distribution is expressible in finite terms which are developed in Section 6.

The (B) distribution of Section 5 replaces the X^2 distribution in the analysis of variance if the squares summed are non-central. An analysis of variance so extended leads to a third group of distributions (C), closely related to (A), and tending like it to a common limit (B). The distinction between (A) and (C) arises from the fact that in cases proper to the multiple correlation the central displacements will vary from sample to sample owing to variations in the second order moment coefficients of the independent variates, and for such cases (A) is the correct distribution. The type (C), however, is of frequent occurrence owing to the absence or irrelevance of such variation.

XIII. R. A. Fisher. "*On a Distribution Yielding the Error Functions of several Well-known Statistics.*" Proceedings of the International Mathematical Congress, Toronto, 1924, pp. 805-813.

When the exact sampling distributions of a number of the statistics in most general use came to be worked out, it appeared that apart from avoidable differences in notation, nearly all were examples of three related types of distribution. Two of these had been previously found and their numerical values made in part available. In 1900, Pearson had established the distribution of his measure of discrepancy X^2 used in testing goodness of fit. Although as given this distribution was incorrect, the correction, so long as efficient methods of fitting are used, does not change the form, but only the particular member of the series to be employed. An identical distribution was subsequently found by "Student" for the variance as estimated from a normal sample, and by the author for the index dispersion for the Poisson and Binomial series. The distribution of t first found by "Student" in studying the mean of a unique sample, is also exact over a much wider range, and gives the distribution also of regression coefficients of all orders. The third distribution, that of z, which may be regarded as a generalisation either of that of X^2 or of t, completes this group of theoretical distributions and supplies the solution for intraclass correlations, the goodness of fit of regression formulæ, the comparison of variances and the significance of multiple correlation and correlation ratios.

XIV. R. A. FISHER AND J. WISHART. *"On the Distribution of the Error of an Interpolated Value, and on the Construction of Tables."* Proceedings of the Cambridge Philosophical Society, 1927. Vol. XXIII., pp. 912-921.

The development of simple interpolation formulæ involving only even differences, has favoured the increased use of formulæ of high order; while the theoretical study of the remainder term makes it possible to design tables for which such formulæ are rigorously valid. This paper develops the theory of the distribution of the error of interpolated values, and shows that these will always have a higher precision than the tabular entries, and if the errors of the latter are normally distributed and independent, those of the former will be normally distributed also, with a variance which for high order formulæ tends to equality. This will not be the case for tables "correct to the nearest figure" in which the error distributions of the tabular entries will be rectangular, and those of the interpolate will have a complicated distribution. The advantages both in convenience and in precision of not cutting down tables as originally calculated, so as to be correct to the nearest figure are therefore to be considered in the publication of tables.

XV. J. WISHART. *"On Errors in the Multiple Correlation Coefficient due to Random Sampling."* Memoirs of the Royal Meteorological Society, 1928. Vol. II., No. 13, pp. 29-37.

The use of the multiple correlation in meteorological and agricultural problems is common where the effect of a number of independently varying factors on, say, the weather of a particular locality, is investigated. An experimental study is made of the kind of values, with their frequency of occurrence, which would arise from chance factors which had in reality no influence on the phenomenon studied. The mathematical theory for this particular case is now complete, and it is shown how the probability of occurrence of any value can be calculated. This method of testing the significance is recommended in place of the more usual probable error, for the distribution is far from normal.

XVI. J. WISHART. *"Table of Significant Values of the Multiple Correlation Coefficient."* Quarterly Journal of the Royal Meteorological Society, 1928. Vol. LIV., pp. 258-259.

This table gives the values of the multiple correlation coefficient that would occur in random sampling from uncorrelated material for the 1 and 5 per cent. levels of significance, and is based on the theory outlined in the preceding memoir. It is carried as far as six independent variates and up to samples of 100.

XVII. J. Wishart. " *Le traitement correct des Problémes de Corrélation Multiple en Météorologie et Agriculture.*" Report of the Association Française pour l'avancement des Sciences, 1928.

The use of the multiple correlation coefficient and its testing by the preceding significance tables is explained, and examples, taken from the weather forecasting work of Sir Gilbert Walker, are worked out. Comment is made on the recent correspondence in " Nature " on the use of the probable error in correlational work.

XVIII. J. Wishart. " *The Generalised Product Moment Distribution in Samples from a Normal Multivariate Population.*" Biometrika, 1928. Vol. XXA., pp. 32-52.

The distribution of the variance was first given by " Student " in 1908. The next advance was in 1915, when R. A. Fisher, for a two-variate population, gave the simultaneous distribution of the three second order moment coefficients, namely the two variances and the cross product moment (or co-variance). In this paper the problem is generalised to include any number of variates, and the multiple distribution of all second order product moment coefficients is deduced. A table follows giving the moment coefficients of this distribution, as far as the fourth order and eight variates.

XIX. J. Wishart. " *A Problem in Combinatorial Analysis giving the Distribution of Certain Moment Statistics.*" Proceedings of the London Mathematical Society, 1929. Series 2, Vol. XXIX., pp. 309-321.

The method outlined in the previous paper for deducing the moments of the distribution from a particular generating function is tedious, and it is here shown that it is, after all, only a particular case of a more general problem whose solution can be reached through the theory of combinatorial analysis. The correspondence between the theories is indicated, and the special problem, which can be considered as a ring arrangement of rods, is worked out in full. Finally, an operational solution is demonstrated, and the arithmetical procedure for building up any required result is illustrated in an example.

XX. J. Wishart. " *Sampling Errors in the Theory of Two Factors.*" British Journal of Psychology, 1928. Vol. XIX., Part 2, pp. 180-187.

It is a mathematical consequence of the theory that any ability can be resolved into two factors, one general and the other specific, that the tetrad difference of correlation coefficients between any four abilities should vanish, within the limits of random sampling error. A modified definition of the tetrad is introduced in order that the distribution reached in Paper No. XVIII. should be capable of application to this problem. An exact formula is then deduced for the standard error of the tetrad, and this is applied to some published results of psychological experiments.

XXI. T. N. HOBLYN. *"A Statistical Analysis of the Daily Observations of the Maximum and Minimum Thermometers at Rothamsted."* Quarterly Journal of the Royal Meteorological Society, 1928. Vol. LIV., pp. 183-202.

Daily records of maximum and minimum temperature at Rothamsted are available for 49 years. This paper gives the means, variances and covariances for each month, and analyses the variance and covariance into portions ascribable to variation from day to day and from year to year.

XXII. R. A. FISHER AND T. N. HOBLYN. *"Maximum and Minimum-correlation Tables in Comparative Climatology."* Geografiska Annaler, 1928. Vol. III., pp. 267-281.

In connection with Paper No. XXI. on Maximum and Minimum Temperature Variations at Rothamsted, the opportunity was taken to prepare and publish for the purposes of comparative climatology two-way tables of these variates for each month of the year for the first 49 years of experience at Rothamsted. The tables are supplemented by Analyses of Variance in which the year to year variation is distinguished from the day to day variation within the same year.

XXIII. R. A. FISHER AND BHAI BALMUKAND. *"The Estimation of Linkage from the Offspring of Selfed Heterozygotes."* Journal of Genetics, 1928. Vol. XX., pp. 79-92.

Five methods of solution are given of the statistical problem presented by typical linkage data. The example chosen shows the various errors into which the use of inefficient statistics leads. Of the efficient methods, the method of maximum likelihood possesses the advantage that it may be applied directly to any analogous problem, and is related in a previously unsuspected way to the measure of discrepancy χ^2. The product ratio method, for using which a table is provided, enjoys the practical advantages of other efficient solutions, and is in addition unaffected by differential viability, if this is caused by one factor only. The method of minimum χ^2, unlike the other two, is laborious in computation and seems to possess no special theoretical interest.

XXIV. R. A. FISHER. *"The Possible Modifications of the Response of the Wild Type to Recurrent Mutations."* American Naturalist, 1928. Vol. LXII., pp. 115-126.

The reaction of the wild type to mutations is known in many cases to be capable of a somewhat rapid modification in experimental conditions, by the selection through differential viability of factors capable of modifying this response.

It may be calculated that with mutation rates of the order of one in a million the corresponding selection in the state of nature, though extremely slow, cannot safely be neglected in the case of the heterozygotes.

The observed behaviour of multiple allelomorphs largely supports, though that of specific modifiers seems to oppose, the view that complete dominance generally may be regarded as a product of such selective modification.

XXV. R. A. FISHER. *"Two Further Notes on the Origin of Dominance."* The American Naturalist, 1928. Vol. LXII., pp. 571-574.

In connection with the previous paper (No. XXIV) the evidence of the behaviour of the cotton mutant, *Crinkled Dwarf*, investigated by Dr. S. C. Harland, is cited as demonstrating the natural evolution of dominance. This mutant is a clear recessive in the Sea Island cottons in which it occurs, but on crossing with other species the dominance of the wild type is found to be conditioned by a group of probably numerous modifiers in which the Sea Island has come to differ from other cottons.

It is suggested that the anomalous dominance of several breed characteristics in domestic poultry may be explained by the incidence of selection in early stages of domestication when the domestic flocks were frequently sired by wild jungle fowls.

XXVI. R. A. FISHER AND L. H. C. TIPPETT. *"Limiting Forms of the Frequency Distribution of the Largest or Smallest Member of a Sample."* Proceedings of the Cambridge Philosophical Society, 1928. Vol. XXIV., pp. 180-190.

The distribution of the greatest or least of a sample of n may be derived from that of the population sampled. If it tends to any limiting form as the size of the sample is increased, its distribution must obey a functional relation the solution of which is here given, with a discussion of the criteria which determine the limiting form, and of the gradual approach to the limit shown in normal samples.

XXVII. R. A. FISHER AND E. B. FORD. *"The Variability of Species in the Lepidoptera, with Reference to Abundance and Sex."* Transactions of the Entomological Society of London, 1929. Vol. LXXVI., pp. 367-384.

The frequency distribution of depth of pigment in the ground-colour of the fore-wings of 35 species of British moths has been obtained by comparison of over 5,000 specimens with a standard colour scale.

For comparison of variabilities of groups of different average tint the standard deviations have been adjusted to eliminate any arbitrary elements which might have been introduced by the scale employed.

The mean tint is darker in the females than in the males, and is also darker in the more abundant than in the less abundant species.

Even after adjustment the mean variance is about 30 per cent. higher in females than in males, and is in both sexes greatest in the abundant species, and at least in those which are less than common.

It is also possible, though the difference is not in this material statistically significant, that the species with wider range are, in any one locality, the more variable.

The association of variability with abundance accords with an early generalisation of Darwin's, and with the theory that variability is determined by a balance between the influences of mutations and selection. This theory is insufficient numerically to account for the large differences in variability between the sexes.

In view of the frequency of polymorphism, and other marked variations, in the females as opposed to the males in Lepidoptera, it is suggested that the male sex hormones may inhibit the action of a number of the factors influencing the development of pigment, as in the well-known sex-controlled variation. The suggestion of Goldschmidt that there exist pigmentation factors in the Y chromosome capable of interaction with outosomal factors to cause pigmentary differentiation is an alternative view which may account for a few cases. This should result in purely female unisexual polymorphism (except for the possibility of occasional crossing-over between the X and Y chromosomes), but it is almost certainly an infrequent phenomenon. It is possible that sexual selection may, in part, be responsible for the complete inhibition of mimetic patterns in the males of certain mimetic species.

XXVIII. R. A. Fisher. "*Triplet Children in Great Britain and Ireland.*" Proceedings of the Royal Society (B), 1927. Vol. 102, pp. 286-311.

Measurements taken at a fixed age of 115 surviving triplet children, are reported upon in respect of the average growth attained, which is not appreciably different from that of children by single births; of the degree of resemblance between pairs of like and unlike sex, which confirm in entirely independent material the conclusion drawn from Lauterbach's measurements of twins; and of the inheritance of the twinning tendency which, in opposition to the view developed by Weinberg, indicates inheritance of diembryony on the paternal side.

XXIX. R. A. Fisher. "*On Some Objections to Mimicry Theory, Statistical and Genetic.*" Transactions of the Entomological Society of London, 1927. Vol. LXXV., pp. 269-278.

The statistical reasoning which led Marshall to dispute the applicability of Müller's theory to the mimetic approach of a more numerous to a less numerous form, is shown to be unsound, and the validity of Müller's argument is verified. The contention of Punnett that in certain cases mimetic forms must have arisen by saltations falls with Marshall's argument on which it is based. The more recent study of modifying factors shows that the Mendelian inheritance observed in polymorphic mimics does not show that these forms were not gradually evolved by natural selection; while the stability of the gene ratio of these factors implies selective action.

III.—THE SOIL.

(a) Mechanical Analysis.

(Chemical, Physical and Statistical Departments.)

XXX. A Sub-Committee of the Agricultural Education Association. *"The Revised Official British Method for Mechanical Analysis."* Journal of Agricultural Science, 1928. Vol. XVIII., pp. 734-739.

A Sub-Committee of the Agricultural Education Association, with Dr. Keen as convenor, proposed in 1926 a new method of mechanical analysis that was officially adopted by the Association. (Papers XXII. and C., Report 1925-26.) At the 1927 meeting of the International Society of Soil Science an agreed international method was adopted which did not differ greatly from the New British method. In consequence, the Agricultural Education Association Sub-Committee decided to make the necessary changes in its recommended method to bring it into line with the international proposals, and the present paper contains an account of the reasons for the change and the actual alterations involved. The full details of the new method, known as the "Revised Official Method," have been accepted and published (see Technical Paper No. CXVIII).

The main differences are that the fractions are weighed as oven dry and not after ignition, and the grouping of the fractions has been altered to the Atterberg scale.

XXXI. E. M. Crowther. *"Nomographs for use in Mechanical Analysis Calculations."*...Proceedings and Papers of First International Congress of Soil Science, Washington, 1928. Vol. I., pp. 399-404.

To facilitate the more general adoption in routine work of the temperature correction for the viscosity of water in mechanical analysis, a nomograph has been prepared giving by a direct reading the times or depths of sedimentation equivalent to those desired at a standard temperature of 20° C. In a second nomograph the logarithms of the settling velocities are connected with (1) the experimental depths and times and (2) the temperature and "equivalent diameter" evaluated on the basis of Stokes' Law.

XXXII. E. M. Crowther. *"The Direct Determination of Distribution Curves of Particle Size in Suspensions."* Journal of the Society of Chemical Industry, 1927. Vol. XLVI., pp. 105-107T.

An apparatus is described for obtaining continuous size distribution curves of suspensions through measurements of the changes with time of the density at a given depth. A highly sensitive differential liquid manometer connected between two points near the base of the sedimenting column is used to secure sufficient magnification for direct readings. Since the readings are proportional to the concentration at a defined depth they may be plotted against the times, or the logarithms of the times, to give directly a summation percentage curve for particle size.

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XXXIII. E. M. CROWTHER. " *A Manometric Apparatus for the Direct Determination of Summation Percentage Curves in Mechanical Analysis.*" Proceedings and Papers of First International Congress of Soil Science, Washington, 1928. Vol. I., pp. 394-398.

See Paper No. XXXI. for abstract.

(*b*) PHYSICAL PROPERTIES.

XXXIV. B. A. KEEN. " *First Commission Soil Mechanics and Physics.*" Soil Science, 1928. Vol. XXV., pp. 9-20.

This is a critical review of recent progress in Soil Physics, partly based on the papers presented to the International Congress of Soil Science, at Washington, D.C., in 1927.

XXXV. B. A. KEEN AND J. R. H. COUTTS. " *'Single Value' Soil Properties : A Study of the Significance of Certain Soil Constants.*" Journal of Agricultural Science, 1928. Vol. XVIII., pp. 740-765.

Numerous attempts have been made to devise an experimental method that, applied to a variety or a series of soils, enables them to be placed in an order closely reflecting their field behaviour or their most important physical characteristics. Such a method is called a " single value " determination, as it endeavours to specify the soil by a single number, in distinction to the group of figures obtained, for example, from a mechanical analysis. A number of these methods are discussed in the present paper, which contains an account of a detailed investigation on 39 soils of certain single value determinations.

The methods selected for study were chosen because (i) they required only simple apparatus, and (ii) they appeared to be related to some distinct characteristic of the soil.

The list of measurements was as follows :—

(*a*) percentage of clay ; (*b*) moisture content of soil in equilibrium with atmosphere of 50 per cent. relative humidity (the ordinary " air-dry moisture content " which was also determined, is close to this value) ; (*c*) ignition loss of the dried soil ; (*d*) moisture content at the " sticky " point, which is defined as the point at which a thoroughly kneaded plastic mass of the soil is just about to stick to the fingers or to a knife.

An important feature of the present investigation was the repetition of the above measurements after the soils had been treated with hydrogen peroxide. Our present knowledge indicates that this removes the humified and non-structural part of the organic matter without exercising more than a small solvent action on the mineral portion of the soil. Comparison of the single-value results for the original and peroxide treated soils thus gives an opportunity of approximately comparing the relative contributions of the organic and mineral parts of the soil. The main results are set out below :—

Correlation coefficients obtained for the various pairs of quantities examined express the general fact that the heavy clay soils have the highest ignition losses, moisture contents and sticky points.

An increased correlation between clay and sticky point for the peroxide treated soils suggest that the sticky point value is controlled both by the organic matter and some property related to the clay content.

When the associations are further examined by partial correlation coefficients, the sticky point is shown to be largely controlled by the colloidal and inorganic colloidal material, while the moisture content at 50 per cent. relative humidity is largely controlled by the actual clay content. There is independent evidence that this moisture is held in the minute interstices between the clay particles.

The sticky point approaches a lower limit of about 16 per cent. moisture content with very sandy soils containing little organic matter. This value is close to 14.6 per cent., which is the saturation moisture content of an ideal soil in closest packing, and it is shown that the pore space of this ideal soil and of the kneaded blocks of actual soil have approximately the same value. Hence the value of the sticky point moisture content is made up of (*a*) 16 per cent. of water held in the pore space, unassociated with colloidal material, and (*b*) water associated with colloidal material. The division of the latter quantity into water associated with organic matter and inorganic clay colloids can be very approximately effected by assuming (i) that the difference between ignition losses of original and peroxide treated soil measures the effective organic matter, and (ii) that the ignition loss of the peroxide treated soil (less the organic matter still present) represents the clay colloid. On these assumptions it appears that the organic colloid takes up about 4.4 times its own weight of water, and the inorganic clay colloid 2.7 times its own weight. The approximate nature of the comparison must be emphasised, owing to the limitations in the assumptions on which it is based. If the actual clay content be taken instead of the ignition loss of the peroxide treated soil, as a measure of the inorganic colloid, the clay on a unit weight basis is only one-ninth as effective as the organic matter.

A comparison is made of the variation of sticky point determinations made by different workers, and it is shown that satisfactory agreement can be secured after a little experience of the method.

The importance is stressed of introducing single value methods as an adjunct to the modern system of soil classification, and into soil physics.

XXXVI. B. A. Keen. "*Some Comments on the Hydrometer Method for Studying Soils.*" Soil Science, 1928. Vol. XXVI., 261-263.

Bouyoucos has developed an empirical method of studying soils, based on the reading of a hydrometer placed in a suspension of the soil in water that has stood for 15 minutes to allow the coarser particles to settle. In Paper No. XXXIV., it was pointed out that the method was essentially qualitative, since an appreciable density gradient must exist in the suspension between top and bottom of the long hydrometer bulb after so short a period as 15 minutes. Later, Bouyoucos (Soil Science, 1925, 25 pp. 365-369) claimed that this statement was not justified, and gave some results to support his claim. The present paper consists of an examination of these figures, which show, as would be expected, that there is an appreciable density gradient, and the actual technique employed by Bouyoucos is then stated in exact physical terms: it consists in measuring at an arbitrary time the average density of a layer of suspension several centimetres in length whose density is continually changing both with depth and time in a manner depending on the particle-size distribution curve of the soil, and therefore varying from soil to soil. The method is therefore essentially qualitative, although in the present state of our knowledge it has some value as an empirical determination.

XXXVII. W. B. HAINES. "*Studies in the Physical Properties of Soils, IV. A Further Contribution to the Theory of Capillary Phenomena in Soil.*" Journal of Agricultural Science, 1927. Vol. XVII., pp. 264-290.

This paper examines in detail the manner in which the moisture in soil is distributed over and between the soil particles. The usual conception of an ideal soil (an assemblage of equal sized spheres in regular packing) is employed, and experimental measurements are made with various materials approximating to this definition. It appears from considerations of the pressure deficiency produced by curvature of the water film surfaces, that there are two possible stable positions for a film of given pressure deficiency: one in which the water exists as an open tunnel, and the other in which the tunnel is filled and closed by a concave film at each end. The fact that these interchangeable forms are possible implies that over a wide range of moisture content the pressure deficiency remains constant, falling rapidly to zero at saturation, and rising theoretically to an infinite value at the dry end of the scale. The experimental results conform this conclusion when allowance is made for the impossibility of packing the material in the regular manner postulated for the ideal soil.

The curve connecting pressure deficiency with percentage of pore space occupied by water is shown also to represent the relation between height above the water table and moisture content at that height for a column of soil whose lower end stands in water.

The suction or pressure deficiency which is necessary to draw an air-water interface into the pores of the soil characterises the capillary behaviour over a considerable moisture range, and the term "entry value" is suggested for it.

XXXVIII. R. A. FISHER. "*Further Note on the Capillary Forces in an Ideal Soil.*" Journal of Agricultural Science, 1928. Vol. XVIII., pp. 406-410.

The new observations of Haines on the pressure deficiency of liquid in a soil-like aggregate confirm the theoretical deduction that the pressure deficiency falls off with increasing water content, but do not justify his belief in a high static stress as saturation is approached.

A theorem is established connecting the static stress at any water content with the pressure deficiency and the dry area of the surface. This, together with general considerations of the energy conditions of physical equilibria, appears to dispose of the two assumptions from which the high values for the cohesive stress at saturation have been deduced.

XXXIX. E. M. CROWTHER. "*Some Physical Properties of Heavy Alkaline Soils under Irrigation* (*in the Sudan Gezira*)." Proceedings and Papers of First International Congress of Soil Science, Washington, 1928. Vol. I., pp. 429-433.

The value of some extremely simple physical methods of studying soil texture is illustrated by measurements on the heavy alkaline soils of the Sudan Gezira. The field density of the soil shows a marked maximum at a depth of 80 cms., but the impermeability to water of the soil at this depth is not entirely due to the closeness of packing, since sieved soil samples, uniformly packed in glass tubes, show a pronounced minimum in the rate of water movement at this depth. The rate of capillary rise of water into sieved soils in glass tubes affords a simple measure of soil texture which is useful for soil survey purposes. In good cotton soils, the rate of capillary rise was about 50 per cent. higher than in bad soils.

XL. B. A. KEEN. "*The Limited Rôle of Capillarity in Supplying Water to Plant Roots.*" Proceedings and Papers of the First International Congress, 1927. Vol. I., pp. 504-511.

The pore space in soils may be regarded as consisting either of an assemblage of small cellular units or of irregular thread-like capillary tubes. The latter conception is the one customarily employed in text-books when the movement of soil moisture is under consideration. It leads, however, to values for the capillary rise of water in soils that are much higher than those found experimentally.

The attainment of equilibrium conditions of moisture in a soil column is a slow process, and moisture distribution conditions in the field are therefore essentially dynamic. The present paper is a preliminary account of the relation between evaporation factors and the daily level of the ground water table in large cylinders of soil exposed to field conditions and kept uncropped. From the data, which included the period of the great drought in 1911, it is possible to construct curves showing how the free water level would fall in an initially water-logged soil during a continuous and unbroken drought. It is found that after the water table has receded some 70 cms. below the surface in a heavy loam soil, the subsequent fall is very slow, and in a further six months the level falls only an additional 20 cms. This slow movement shows that capillary action is practically ineffective in raising water through a higher distance than 60-80 cms. in a heavy soil under field conditions, and the result emphasises the importance of those cultivation methods intended to protect the moisture supply in the soil from evaporation at the surface.

XLI. G. W. Scott Blair and E. M. Crowther. "*The Flow of Clay Pastes through Narrow Tubes.*" Journal of Physical Chemistry, 1929. Vol. XXXIII., pp. 321-330.

Laboratory studies of the physical and physico-chemical factors concerned in the production of soil tilth in the field can be made in a variety of ways. This paper gives an account of the behaviour of clay and soil pastes when they are forced through a capillary tube under pressure. The experimental method has been used by a number of workers and for a wide range of plastic materials, but neither the apparatus nor the theoretical treatment can be regarded as completely satisfactory. Improvements were therefore introduced in the design of the apparatus: a bulb is provided at each end of the capillary and the paste is sheared alternatively from one bulb to the other; the apparatus is bodily tilted during the experiment to keep the level of the paste in the two bulbs the same, so that no correction is required for hydrostatic head; the amount of flow under given constant pressure is measured by a calibrated flowmeter consisting of a sensitive inclined alcohol manometer that records the pressure of the displaced air as it escapes through one of a series of capillaries, selected as convenient for the velocity of paste flow under measurement.

It is known that the relationship between the amount of material flowing in unit time and the pressure applied is not the simple proportionality obtained with true fluids under the same conditions for which the Poisuille equation holds. Numerous attempts have been made to obtain a modified Poiseuille equation for the flow of pastes. The one here considered is due to Buckingham who predicted that with increasing pressures the material would flow successively as (*a*) a solid plug, (*b*) a solid plug moving in an outer stream line sheath, (*c*) entirely stream line flow. These conclusions are shown experimentally to be correct, but in addition there is a stage that precedes the plug flow, in which no movement at all occurs until the pressure reaches a certain minimum value; the necessary modification of the Buckingham equation to include this effect is given. When the volume of flow in unit time is plotted against the pressure employed, the points for the plug flow and the complete stream line flow lie on straight lines. A constant independent of the diameter of the capillary can be derived from the slope of each line, and the ratio of these constants is independent of the concentration of the material used over a wide range. The value of the ratio appears to depend on the nature and geological origin of the material.

XLII. G. W. Scott Blair. "*Ueber die Geschwindigkeitsfunktion der Viskositat disperser Systeme.*" (On the speed-function of Viscosity in disperse systems), "Kolloid Zeitschrift." 1929. Vol. XLVII., pp. 76-81.

Ostwald and his school have for some years been collecting a great mass of data relating the amount of material passing through a capillary tube in unit time and the pressure applied to the material. For colloidal materials which are not true fluids many other workers have found that for a certain region of pressures a straight line is obtained by plotting the pressure direct against the flow per unit time, though this straight line does not pass through the origin.

Ostwald's treatment, however, is more elaborate and involves the logarithms of the pressure and flow. This necessitates the friction coefficient (equivalent to viscosity in a pure fluid) having dimensions dependent on the material used and on the conditions of experiment.

In this paper it is shown that much of the data obtained by Ostwald and others can be equally well interpreted on the simple relationship already mentioned. This has the further advantage that the friction coefficient is of normal dimensions.

(c) Soil Cultivation.

XLIII. W. B. Haines and B. A. Keen. *" Studies in Soil Cultivation, IV. A New Form of Traction Dynamometer."* Journal of Agricultural Science, 1928. Vol. XVIII., pp. 724-733.

The original form of dynamometer (Report 1925-26, Paper XXX.) has now been replaced by a new type described below that has many advantages.

The instrument consists of (*a*) an hydraulic link weighing 16lb., and placed in the hitch, (*b*) a recording mechanism weighing 15lb., carried on any convenient part of the implement, and (*c*) a control box weighing 4lb., carried by the operator. When packed in a stout box for transit, and with all accessories, the total weight is less than 100lb. The instrument is of robust construction, and has a minimum number of moving parts. Adjustments for stylus pressure, etc., are provided, but the necessity for using them hardly ever arises.

The instrument operates by recording the amount of movement in a Buordon tube filled with oil and connected by narrow bore copper tubing to the oil in the hydraulic link. A number of Bourdon tubes is provided, of different strengths. These tubes are easily interchangeable so that the instrument can be used, with the same percentage accuracy for all types of work from the lightest to the heaviest.

XLIV. W. B. Haines and B. A. Keen. *" A New Dynamometer, suitable for all types of Horse and Power-Drawn Implements."* Proceedings and Papers of the First International Congress of Soil Science, Vol. I., Part II., pp. 405-411.

See Paper No. XLIV. for abstract.

XLV. B. A. Keen. *" The Value of the Dynamometer in Cultivation Experiments and in Soil Physics Research."* Proceedings nd Papers of the First International Congress of Soil Science, 1927. Vol. I., pp. 412-428.

This Paper summarises the work already described in Papers XXX., XXXI., and XXXII., of the 1925-26 Report. In addition an account is given of later work in which variations in the resistance of the subsoil were recorded by the dynamometer during the operation of mole drainage. The field in question was known to have an irregular subsoil, patches of gravel occurring in the clay. The boundaries and extent of these patches were sharply defined by the dynamometer results, and it was therefore possible to construct a map giving their positions in detail. Without the dynamometer this information would only have been obtained—and only then in a very approximate form—by laborious digging or boring of many holes.

(*d*) ORGANIC CHEMISTRY.

XLVI. H. J. PAGE AND C. E. MARSHALL. *"The Origin of Humic Matter."* Nature, 1927. Vol. CXIX., p. 393.

Fractionation of humic material by sulphurous acid gave substances resembling lignosulphonic acids. The possible relationship between lignin and natural humic acids is discussed.

IV.—THE SOIL POPULATION AND ITS BEHAVIOUR.

(Bacteriological, General Microbiology, Mycological, and Entomological Departments.)

(*a*) BACTERIA.

XLVII. E. J. RUSSELL. *"The Present Status of Soil Microbiology and its Bearing upon Agricultural Practice."* Proceedings and Papers of the First International Congress of Soil Science, June, 13-22, 1927, Washington, D.C. Vol. I.

XLVIII. P. H. H. GRAY AND H. G. THORNTON. *"Soil Bacteria that Decompose Certain Aromatic Compounds."* Centralblatt fur Bakteriologie Abt. II., 1928. Vol. LXXIII., pp. 24-96.

Many types of soil bacteria have been isolated that can decompose the aromatic compounds phenol, meta-cresol, and naphthalene, which are used as soil sterilising agents. Several of them can also utilise one or more of the following compounds: ortho-cresol, para-cresol, phloroglucinol and resorcinol. One organism has been isolated that can utilise toluol. Pure cultures of the bacteria use these compounds as sole sources of energy in mineral salts media containing inorganic nitrogen. Organisms without spores grew in media containing 0.1 per cent. phenol, but were killed by a concentration of 0.2 per cent. The bacteria are widely distributed in Great Britain, and have been found in soils from Norway, the Tyrol, and from islands in the South Atlantic. They are most often found in arable soil and, in the Rothamsted plots, rarely occur in unmanured soil. One species (*Mycobacterium agreste* n.sp.) is more abundant in dry than in wet districts. Out of 245 soil samples examined, 146 yielded the bacteria, and from these 208 strains were isolated that attack either phenol, meta-cresol, or naphthalene. From a study of their morphology and growth characters the strains have been classified into seven genera and 25 species, which are described. A new genus, *Mycoplana*, has been formed to include an aberrant type having motile branch cells. When soil is treated with phenol an increased bacterial population ensues, which is composed largely of one morphological type (*Micrococcus sphaeroides* n.sp.) that can decompose phenol in pure culture.

XLIX. H. G. Thornton. "*The Influence of the Number of Nodule Bacteria as Applied to the Seed upon Nodule Formation in Legumes.*" Journal of Agricultural Science, 1929. Vol. XIX., pp. 373-381.

In a field trial with lucerne grown from seed treated with varying doses of culture, it was found that the numbers of nodules were increased as the dose was raised from 2,500 to 20,000 organisms per seed (56 to 7lb. of seed per culture). Storing the seed for periods up to 28 days between inoculation and sowing caused some loss in the nodule numbers. This loss was greatest between 1 and 7 days' storage.

The difference in dose of culture and in period of storage did not significantly affect the crop subsequently obtained from the inoculated plots, whose yield was, however, much above the uninoculated. In a pot experiment made with runner beans, it was found that increase in the dose of culture above 1,280,000,000 organisms per pot containing six seeds was still capable of increasing nodule numbers but not to an extent proportional to the increase in dose.

The experiment does not exclude the possibility that the restriction in effect of very heavy doses may be due to the soil population becoming saturated with the bacteria. On the other hand, observations on lucerne plants grown aseptically on agar and inoculated with a pure culture, showed that even when excessive numbers of bacteria immediately surrounded the root hairs, only 4 per cent. of these were infected.

L. H. G. Thornton. "*The Rôle of the Young Lucerne Plant in Determining the Infection of the Root by the Nodule Forming Bacteria.*" Proceedings of the Royal Society (B), 1929, pp. 481-492.

The appearance of nodules on seedlings of Lucerne (*Medicago sativa. L.*) coincides with the opening of the first true leaf. There is evidence that before this leaf opens the nodule bacteria do not, as a rule, infect the root-hairs.

The delayed infection is due to the plant, and not to any delay in the development of infective power by the bacteria.

When young inoculated seedlings whose first leaves are still closed are grown intermingled with older plants a considerable number of nodules will develop on them, although scarcely any are formed on control seedlings of the same age, grown by themselves.

The solution surrounding the roots of seedlings whose first leaves are expanded, has an influence in stimulating the appearance of nodules on younger seedlings and increases the growth of the nodule organism on agar. The solution surrounding the roots of younger seedlings has no such effect.

The active substance inducing nodule appearance when the first leaf opens is not formed in this leaf, since the removal of the leaves while still closed has no effect on nodule appearance.

LI. H. G. THORNTON. *"The 'Inoculation' of Lucerne (Medicago sativa) in Great Britain."* Journal of Agricultural Science, 1929. Vol. XIX., pp. 48-70.

The Paper discusses experiments laid down at 39 centres in Great Britain to test the value of seed inoculation for lucerne. In the West and North of England the treatment greatly benefited the lucerne and often enabled a crop to be obtained where the untreated lucerne failed.

In the midland and south-central counties, inoculation usually produced a temporary improvement, the untreated plant eventually catching up with the inoculated. In East Anglia and Kent, untreated lucerne usually developed plenty of nodules. There is evidence that, when the seed is inoculated, the chances of success with lucerne are on the whole as good in the West and North of England as they are in the South-east.

LII. H. L. JENSEN. *"On the Influence of the Carbon-Nitrogen Ratios of Organic Material on the Mineralisation of Nitrogen."* Journal of Agricultural Science, 1929. Vol. XIX., pp. 71-82.

Organic materials with a C:N ratio ranging from about 85:1 to about 10:1 were submitted to nitrification tests in an acid and in an alkaline soil during a period of 6 months. In the acid soil only pea pod meal, with a C:N ratio of 13.3:1 showed an increase in inorganic N over control; in the alkaline soil the limit above which no nitrification will occur within a period of 6 months was at C:N = 26:1; below this limit the rate of nitrification increased rapidly, with decreasing C:N ratio. Unnitrified N was left behind in a quantity corresponding to 1.5-2.2 per cent. of the original material, the percentage being higher in the case of materials rich in N.

All the materials tended to increase the content of "α humus" in the soil, though not to the same extent or in the same manner. More "α humus" was produced in the alkaline than in the acid soil, except in the case of farmyard manure. Straw, sweet clover, lupin and farmyard manure apparently acted both through their lignin content and through the synthesising action of micro-organisms, since they increased the amounts of both N and methoxyl in humus. Mycelium of *Polyporus* contains a fraction possessing the properties of "humic acid," rich in N, but devoid of methoxyl, which persists in the soil.

The experiments show that the carbon-nitrogen ratio is a factor which exerts an influence on nitrification as profound as that of soil reaction, and that the less complete utilisation of farmyard manure nitrogen as compared with nitrogen in artificial fertilisers can to a large extent be explained hereby.

LIII. P. H. H. GRAY. *"The Formation of Indigotin from Indol by Soil Bacteria."* Proceedings of the Royal Society (B), 1928. Vol. CII., pp. 263-280.

A study of the physiology and biochemistry of new species of soil bacteria that decompose the toxic compound indol, with especial reference to the action of *Pseudomonas indoloxidans.* The indol is converted rapidly into the insoluble indigotin; for this reaction the organism needs a source of energy such as amino-acids, dextrose, glycerol, fatty acids, or alcohols. The conversion is effected quantitatively and appears to be carried out by means of an extra-cellular enzyme.

LIV. P. H. H. Gray and H. G. Thornton. "*The Estimation of Bacterial Numbers in Soil by Direct Counts from Stained Films.*" "Nature," 1928. Vol. CXXII., pp. 140-141.

A preliminary note concerning a new method of counting soil bacteria by direct observation through the microscope.

(*b*) Protozoa.

LV. D. Ward Cutler and A. Dixon. "*The Effect of Soil Storage and Water Content on the Protozoan Population.*" Annals of Applied Biology, 1927. Vol. XIV., pp. 247-254.

Stored soil is a suitable medium for experiments on micro-organisms provided that the ratio of surface to volume is relatively high. The water content of soil, if sufficiently low (1/6 to 1/5 the water-holding capacity) may act as a limiting factor for soil protozoa, but above this amount changes in the water content are without effect.

LVI. C. E. Skinner. "*The Effect of Protozoa and Fungi on Certain Biochemical Processes when Inoculated into Partially Sterilised Soil.*" Soil Science 1927. Vol. XXIV., pp. 149-161.

In partially sterilised soils inoculated with bacteria *Hartmanella hyalina* and with bacteria alone, the presence of the amoebae caused a reduction in the bacterial numbers and a slight depression in carbon dioxide production and ammonia accumulation. The presence of *Trichoderma köningi* and *Penicillium* sp. increased carbon dioxide production but decreased the accumulation of ammonia.

LVII. D. Ward Cutler and L. M. Crump. "*The Qualitative and Quantitative Effects of Food on the Growth of a Soil Amoeba (Hartmanella hyalina).*" British Journal of Experimental Biology, 1927. Vol. V., pp. 155-165.

The reproductive rate in *Hartmanella hyalina* varied directly with the available bacterial food supply. It is shown that three species of soil bacteria have different feeding values both in respect of the rate of division of the amoebae, and also of the total increase in protoplasm.

LVIII. A. Dixon. "*The Effect of Phenol, Carbon Bisulphide and Heat on Soil Protozoa.*" Annals of Applied Biology, 1928. Vol. XV., pp. 110-119.

Phenol has a greater lethal effect than has carbon bisulphide upon protozoa. Steaming glasshouse soil destroys the majority of protozoa and depresses their numbers for a considerable period of time.

LIX. H. SANDON. "*A Note on the Microbiology of Wicken Fen Soils with Special Reference to the Protozoa.*" Natural History of Wicken Fen, 1928. Part IV., Section 35, pp. 366-370.

In connection with the ecological survey of Wicken Fen, Cambridge, eight samples of peat soils were examined. The protozoa found in them are recorded together with the results of counts of bacteria and of actinomycetes. The rôle of micro-organisms in fen soils is briefly discussed.

LX. H. SANDON. "*A Study of the Protozoa of some American Soils.*" Soil Science, 1928. Vol. XXV., pp. 107-122.

Protozoa and other micro-organisms were counted in a number of soil samples from the experimental plots at the New Jersey Experiment Station. Wide variations were found in samples taken at different dates but, on the whole, numbers were low compared with those obtained from similar plots at Rothamsted. A neighbouring soil (Penn loam) gave much higher figures. Considerable numbers of protozoa were present even during severe frost, but rapid increases occurred after thawing and the numbers then reached were much higher than at other times in the year. Counts were also made on dry, irrigated and alkaline soils at Logan, Utah, and some degree of activity was indicated in them all.

The kinds of protozoa are very similar in all soils so far examined, and their numbers are roughly proportional to the numbers of bacteria present.

(*c*) FUNGI.

LXI. W. B. BRIERLEY, S. T. JEWSON AND M. BRIERLEY. "*The Quantitative Study of Soil Fungi.*" Proceedings and Papers of the First International Congress of Soil Science, 1927. Vol. III., pp. 1-24.

A summary of investigations on the quantitative estimation of soil fungi. The plating technique is divided into its component factors :—(A)Factors of Sampling : (1) methods of sampling, (2) amount of sample, (3) depth distribution of fungi in relation to sampling, (4) storage of samples, (5) comparison of samples ; (B) Factors of Suspension : (1) sampling of sample for primary suspension, (2) shape of container, (3) suspension liquid ; (C) Factors of Disintegration : (1) method of disintegration, (2) violence and duration of shaking ; (D) Factors of Dilution : (1) method of dilution, (2) degree of dilution ; (E) Factors of Plating : (1) method of plating, (2) number of plates, (3) size of plates, (4) amount of medium, (5) composition of medium, (6) acidity of medium, (7) competition on plates ; (F) Factors of Incubation : (1) period of incubation, (2) temperature of incubation ; (G) Factors of Counting : (1) method of counting. These factors are studied independently and in combination and it is shown that if they are rigidly standardised a technique is obtained which gives a satisfactory degree of accuracy in replication experiments.

LXII. E. McLennan. "*The Growth of Fungi in Soil.*" Annals of Applied Biology, 1928. Vol. XV., pp. 95-109.

Sterile soil was inoculated with a known quantity of spores of four different fungi, incubated at 9° C. and at intervals representative samples were plated out by the dilution method and an analysis of the plate population made. Results showed that high plate counts were not in any way connected with vegetative growth and supported Conn's idea that in such a case one is simply measuring the sporing capacity of the forms used.

Samples of moist soil and of soil which had been dried in a vacuum desiccator over calcium chloride were plated out by the dilution method and the number of fungal colonies per plate compared. A marked decrease was noted with the dried sample. The reduced pressure was found to have no effect as drying under ordinary air-pressure gave comparable results.

Suspensions in soil, and in sand, of fragmented mycelia and of a mixture of fungal spores, were in turn plated out directly and after drying. No colonies developed from the sample in the desiccator containing only mycelia, whereas the sample containing spores was in no way affected. It is suggested therefore that the decrease obtained after drying is due to the desiccation of the vegetative mycelium in the soil and since the reduction in the number of colonies per plate is very pronounced after this treatment, it is thought that the normal fungal constituents of the soil are present extensively in the mycelial condition.

(*d*) Algæ.

LXIII. B. M. Bristol Roach. "*On the Algæ of some Normal English Soils.*" Journal of Agricultural Science, 1927. Vol. XVII., pp. 563-588.

An account of an investigation of the algal-flora of four English soils by means of dilution cultures of freshly gathered samples of soil from the top, second, fourth, sixth and twelfth inch depths and from the top 6in. mixed. A counting method is described applicable to the green algæ and diatoms, by means of which it is shown that these algæ are distributed throughout the top 12in. of soil, though at the sixth and twelfth inch depths they are considerably less numerous than nearer the surface. At the fourth inch depth the numbers of individuals are not significantly smaller than on the surface and may be even greater.

The unmanured plot of Broadbalk wheat field was found to contain the same main species as the adjacent farmyard manure plot, but was poorer in number of individuals. Thirty-five species are described from each plot; they seem to be divisible into two groups, the true soil forms and casual species. Of the true soil forms some grow equally well on the surface and in the lower layers, whereas others are more numerous on the surface than within the soil. The same main types were also obtained from Barnfield and from a cottage garden, but the blue-green species were less conspicuous in both of these soils.

Experimental evidence is given to show that many of the algæ of the soil exist in a vegetative condition rather than a resting condition. Biological notes are made on some of the more important or interesting soil species.

LXIV. B. M. Bristol Roach. *"On the Carbon Nutrition of some Algæ Isolated from Soil."* Annals of Botany, 1927. Vol. XLI., pp. 509-517.

An account is given of the growth, both in daylight and in complete darkness, of five species of soil algæ, isolated in pure culture, on media containing mineral salts enriched with various sugars. It is shown that all five species are capable of growing in complete darkness, provided that a suitable organic compound is present in the medium, and may therefore be regarded as true soil algæ, but that the five species react quite differently to the conditions imposed upon them, and that they vary considerably in the extent to which they are able to grow in the dark. It is concluded that it is not justifiable to regard the soil algæ as a homogeneous physiological unit in considering the relation which these organisms bear to the problems of soil fertility.

LXV. B. M. Bristol Roach. *"On the Influence of Light and of Glucose on the Growth of a Soil Alga."* Annals of Botany, 1928. Vol. XLII., pp. 317-345.

Scenedesmus costulatus, Chod., var. chlorelloides, Bristol Roach, grows in liquid cultures at different rates according to the external conditions imposed upon it, and there appears to be some internal factor which limits the growth of the organism at a temperature of 24.5° C. to a maximum rate in the light represented by the figure 0.47-0.475. The maximum rate of growth is realised under purely photosynthetic conditions with a comparatively strong light intensity, and the addition of glucose to the medium produces no significant increase.

As the light intensity diminishes and the rate of growth by means of photosynthesis becomes less, the alga absorbs glucose directly from the medium to supply the deficiency due to retarded photosynthesis, but only in such quantity as will bring the total growth rate up to the maximum figure. As the intensity of the light continues to diminish, the alga absorbs increasing amounts of glucose up to a maximum quantity, which is approximately equivalent to the amount assimilable when the alga is grown in complete darkness with glucose as its sole source of carbon.

With light of low intensity, when the rate of growth due to photosynthesis is low, the total rate of growth of the alga possible in a glucose medium is equal to the sum of the rates due to photosynthesis alone and to the maximum amount of glucose assimilable in the dark.

With low and moderate intensity of illumination, the rate of increase of the growth rate in a mineral salts medium due to photosynthesis alone appears to be directly proportional to the rate of increase in light intensity, until a certain illumination of optimum efficiency is reached; beyond this optimum successive increases in light produce progressively smaller increments in growth rate as the alga approaches more clearly to its maximum rate of growth.

LXVI. B. M. Bristol Roach. *"The Present Position of our Knowledge of the Distribution and Functions of Algæ in the Soil."* Proceedings and Papers of the First International Congress of Soil Science, 1927. Vol. III., pp. 1-9.

A summary: special attention is given to the distribution of algæ in the soil, to methods for distinguishing between resting and vegetative cells, to the carbon nutrition of soil algæ and to the nitrogen cycle in the soil.

(*e*) Insects.

LXVII. H. M. Morris. *"The Insect and other Invertebrate Fauna of Arable Land at Rothamsted, Part II."* Annals of Applied Biology. Vol. XIV., 1927, pp. 442-464.

Samples of soil were taken from six of the plots of Barn Field on the farm of the Rothamsted Experimental Station, and insects and other invertebrates found therein are recorded together with the approximate depth at which they occurred. Of these plots one receives no manure, one superphosphate only and one ammonium salts only, while of the other three, all of which receive dung, one receives superphosphate and potash, and another ammonium salts in addition. The total number of insects and other invertebrates per acre in the undunged plots were 1,208,000, 1,410,000 and 1,734,000 respectively. Of these, 673,000, 999,000 and 1,424,000 respectively were insects. Similarly in the dunged plots the total numbers of insects and other invertebrates per acre were 12,948,000, 9,448,000 and 10,516,000 respectively, and of these 2,323,000, 2,215,000 and 4,677,000 respectively were insects. Each sample was taken in five layers so that it was possible to record the approximate depth at which each individual occurred. The greatest number, both of insects and of other invertebrates, occurred in the upper five inches of the soil. It appears that artificial manures have little or no effect on the soil fauna, while the effect of dung in increasing the fauna is very considerable.

V.—THE PLANT IN DISEASE; CONTROL OF DISEASE.

(Chemical, Entomological, Insecticides and Fungicides, and Mycological Departments.)

(*a*) Insect Pests and their Control.

LXVIII. H. F. Barnes. *"The British Gall Midges of Peas."* Bulletin of Entomological Research, 1928. Vol. XIX., pp. 183-185.

In Britain three species of gall midges exist whose larvæ may be found in pea pods: the pea midge, *Contarinia pisi,* which is the most common and is sometimes a pest; *Lestodiplosis pisi,* a predator on the former; and *Clinodiplosis pisicola,* an inquiline. The larvæ of these three species are discussed and the last-named midge is described in detail for the first time.

LXIX. H. F. Barnes. *"Wheat Blossom Midges (Cecidomyidæ, Diptera). Differences between 'Contarinia tritici' (Kirby) and 'Sitodiplosis mosellana' (Gehin)."* Bulletin of Entomological Research, 1928. Vol. XVIII., pp. 285-288.

In the past, wherever Cecidomyid larvæ have been found in the ears of wheat, the presumption has been that the species concerned was *C. tritici* : this error has been made both in England and North America. It is shown that in the vast number of cases of infection the species concerned is *S. mosellana*, which attacks the kernel and not the anthers as in *triciti*. Full descriptions and figures are given for separating the two species in question.

LXX. J. Davidson. *"On Some Aphides infesting Tulips."* Bulletin of Entomological Research, XVIII., Sept., 1927, pp. 51-62.

A detailed technical description is given of three species of aphids obtained from various sources on tulip bulbs and iris corms. These species were reared and observations made on the progress of infestation on tulips. *Anuraphis tulipæ* is shown to be a serious pest of stored bulbs, and when the latter are grown early in the season in glasshouses, multiplication becomes rapid on the growing leaf-spathes which leads to distortion of the plants. The other species, viz., *Rhopalosiphoninus tulipælla* and *Macrosiphum gei* are of less importance : the first mentioned along with *Anuraphis tulipæ* have up to the present been imperfectly known and detailed figures illustrating their distinctive characters given. Infested stored bulbs should be collected and subjected to treatment in order to prevent widespread infection of other bulbs in the same store and various methods of treatment are given.

LXXI. J. Davidson. *"On the Occurrence of the Parthenogenetic and Sexual Forms in Aphis rumicis, with Special Reference to the Influence of Environmental Factors."* Annals of Applied Biology, 1929. Vol. XVI., pp. 104-134.

This Paper discusses in detail experimental evidence as to the factors which tend to the production of alate dispersal forms, apteræ and sexuales. Especially notable are the effects of overcrowding on the host plant leading to the production of alate forms : the effects of removal of the growing points of bean plants on the degree of infestation of the latter by the aphids : and the effects of duration of daylight and temperature on the incidence of the sexual forms.

LXXII. W. M. Davies. *"The Effect of Variation in Relative Humidity on Certain Species of Collembola."* British Journal of Experimental Biology, 1928. Vol. VI., pp. 79-86.

It was found that, with the exception of the genus *Entomobrya,* Collembola devoid of a tracheal system, are very susceptible to atmospheric dryness. Species which possess a tracheal system are capable of withstanding complete dryness for a period of 10 hours or double the maximum time found for non-tracheate forms. The influence of variation in relative humidity in the death-rate of various species has been studied, and at a uniform temperature of 25° C. a saturated atmosphere was found necessary for survival. The work has a definite practical bearing, since it explains why methods of controlling *Bourletiella hortensis* require to be carried out in early morning or after heavy rain during the day : at other times this insect retreats below the soil.

LXXIII. W. M. DAVIES. *"The Bionomics of Apion ulicis (Gorse Weevil) with Special Reference to its Rôle in the Control of Ulex europæus in New Zealand."* Annals of Applied Biology, 1928. Vol. XV., pp. 263-286.

The external morphology of this species in its different stages is described and the details of its biology and feeding habits are given. The effects of the feeding of the adults and larvæ on the host plant are described, together with tabular results of a study of pod infection from samples taken from 62 districts in Great Britain. As high as 92 per cent. infection was observed in some cases. Prolonged tests were carried out with respect to the possibility of the *Apion* attacking cultivated leguminous plants. but gave negative results. The species is considered valuable for the purpose of attempting the control of the spread of gorse in New Zealand and shipments have been made to that country for this purpose.

LXXIV. F. TATTERSFIELD AND C. T. GIMINGHAM. *"Studies on Contact Insecticides, Part V. The Toxicity of the Amines and N-Heterocyclic Compounds to 'Aphis Rumicis L'."* Annals of Applied Biology, 1927. Vol. XIV., pp. 217-239.

The toxicities to *Aphis rumicis* of certain alipathic and aromatic amines and of some of the simpler nitrogen-heterocyclic derivatives have been quantitatively determined.

Tetramethylammonium hydrate and chloride are more toxic than the corresponding tetraethylammonium compounds. This is in keeping with the findings of Dale and his co-workers, who have shown that tetramethylammonium has certain physiological effects similar to those of nicotine, which are not shown by tetraethylammonium.

The aromatic amines, on the whole, show little insecticidal action. Aniline and most of the aliphatic anilines are only slightly toxic to *A. rumicis*. The substitution of aromatic groups in the amino group of aniline increases toxicity more than the substitution of aliphatic groups. There are interesting relationships in regard to toxicity among these compounds.

o-Nitraniline is one of the most toxic of the aniline derivatives.

Among the heterocyclic compounds, nicotine is highly poisonous to *A. rumicis*. The heterocyclic rings constituting the molecule of nicotine are much less toxic than nicotine itself; pyrrole and pyridine show comparatively slight insecticidal action. The

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order of increasing toxicity of the simpler N-heterocyclic compounds is pyrrole, pyridine, picoline, lutidine, quinoline and isoquinoline, acridine.

Hydrogenation of pyridine and pyrrole increases their toxicity, piperidine is more toxic than pyridine and pyrrolidine than pyrrole.

Benzyl-pyridine is the most toxic pyridine derivative tested.

LXXV. F. Tattersfield and C. T. Gimingham. *"Studies on Contact Insecticides, Part VI. The Insecticidal Action of the Fatty Acids, their Methyl Esters and Sodium and Ammonium Salts."* Annals of Applied Biology, 1927. Vol. XIV., pp. 331-358.

The toxicities to *Aphis rumicis L.* of the fatty acids from formic to stearic and of the sodium and ammonium salts and methyl esters, applied as spray fluids, have been quantitatively determined. Two unsaturated acids, undecenoic and oleic, are included.

There is a rise in toxicity of the acids with increase of molecular weight as the series is ascended from acetic to undecylic acid. Formic acid is exceptional. Beyond undecylic acid, there is a fall in toxicity, and acids higher in the series than tridecylic, show only slight toxic action.

The sodium salts of the fatty acids are in most cases much less toxic than the corresponding acids, though the difference is less marked with the higher acids. Oleic acid and sodium oleate are of the same order of toxicity.

The ammonium salts are generally less toxic than the corresponding acids, but the differences are much less than in the case of the sodium salts. With some of the higher acids, *e.g.*, myristic and oleic, neutralisation with ammonia increases toxicity. The relatively high toxicity of the ammonium salts may be due, at least partly to liberation, by hydrolysis, of free fatty acid in a very finely divided state.

Methylation of the fatty acids reduces toxicity; all the methyl esters are less toxic than the acids or ammonium salts.

Both the ammonium salts and the methyl esters show, like the acids themselves, increase of toxicity with increase of molecular weight up to a certain point. The formates are exceptional.

The fatty acids do not show marked toxicity to the eggs of *Selenia tetralunaria* Hüfn. at concentration below 2 per cent.

Possible relationships between certain physical properties (physical state, volatility, dissociation constants, partition coefficients and surface tension) of the fatty acids and their insecticidal action are discussed.

Determination of partition coefficients as between olive oil and water and comparison of the figures with the relative toxicities show a steady rise in toxicity with a decrease in the partition coefficients (water/oil) from acetic to capric acid. Formic acid is again exceptional. With lauric and oleic acids there is a break in correlation. The bearing of the solubility relationships of the acids on these results is considered.

LXXVI. F. Tattersfield. "*The Relationship between the Chemical Constitution of Organic Compounds and their Toxicity to Insects.*" Journal of Agricultural Science, 1927. Vol. XVII., pp. 181-208.

An analysis is made of the relationships between chemical constitution and insecticidal action in the vapour phase. There is rough correlation between the molecular weights and volatilities of organic compounds and toxicity, but it is probable that these relationships are only indirectly involved and that they indicate a connection of a more direct kind with some other property such as adsorption.

An account is given of the toxicity to insects of certain plant products. The most potent of these are certain tropical leguminous plants used as fish-poisons. A brief account is given of the chemical derivatives found in these plants. One of them, "tubatoxin," is one of the most potent contact insecticides known.

A list of the groups of organic chemicals tested for their toxic action on *Aphis rumicis* and the eggs of *Selenia tetralunaria* is given. A more detailed account is given for each group of the relationships between chemical constitution and insecticidal action. It is shown that the substitution of certain radicals in the benzene ring profoundly affects toxicity, but that toxic action depends not only upon the radicals, but the number substituted and, in certain cases upon their relative position.

An analysis is made of the bearing of certain of the physical properties of these acids upon toxicity; such are volatility, physical state, partition coefficients, dissociation constants and surface tensions of their solutions in water. None of these properties entirely accounts for the toxicities shown by the fatty acids, but to a certain extent with some of them correlation is sufficiently close to indicate the necessity of further study but on simplified lines.

LXXVII. F. Tattersfield. "*The Decomposition of Naphthalene in the Soil and the Effect upon its Insecticidal Action.*" Annals of Applied Biology, 1928. Vol. XV., pp. 57-80.

When naphthalene is incorporated thoroughly with soil, it shows a fairly potent toxic action on wireworms; uneven distribution lessens its efficiency as, owing to its low vapour pressure and consequent slow, spread, it produces only a small zone of toxic action.

The persistence of the toxic action depends upon the soil type. In soils rich in organic matter, toxicity disappears more rapidly than in soils less rich in organic matter. Toxicity persists longer in sterile soils and in sand than in unsterilised soils, and in dry than in moist soils.

The rate of disappearance of naphthalene from soil has been determined. It depends very little upon volatilisation, but almost entirely upon some factor inherent in the soil, which is more active in soils rich in organic matter than those poor in organic matter, and in unsterilised soils than in sterile soils.

The bacterial numbers of the soils are at first decreased by the addition of naphthalene, but there is a rapid rise during the period when acceleration in the rate of decomposition of the naphthalene is taking place. All the evidence indicates that the loss of naphthalene from the soil is mainly due to bacterial decomposition.

Methods of estimating naphthalene are described. They depend on formation of naphthalene picrate. Picric acid can be more readily titrated by alkali in orange and yellow coloured light than in white light.

LXXVIII. J. C. F. Fryer, F. Tattersfield and C. T. Gimingham. *"English-grown Pyrethrum as an Insecticide, I."* Annals of Applied Biology, 1928. Vol. XV., pp. 423-445.

The toxicity to *Aphis rumicis L.* and to certain caterpillars of spray fluids prepared from samples of pyrethrum (*Chrysanthemum cinerariæfolium*) grown in England from Swiss and Japanese seed, have been quantitatively determined.

Pyrethrum flowers, grown in six different localities, showed only slight differences, and, for practical purposes, all the samples had approximately the same toxicity. They did not differ in this respect significantly from a sample grown on the continent.

The toxicities of extracts of equal weights of pyrethrum flowers tested at different stages of development differed very little. Artificial drying of the flowers had no significant effect on the toxic properties. The flowers were about ten times as toxic as the stalks, weight for weight. Prolonged exposure of pyrethrum to wet conditions led to some loss of toxicity, but contrary to the usual opinion, if stored in a reasonable manner, it remained for long periods without deterioration. Caterpillars of different species showed marked differences in susceptibility to the action of pyrethrum. The biological method employed has proved suitable for evaluating samples of pyrethrum.

LXXIX. C. T. Gimingham and F. Tattersfield. *"Laboratory Experiments with Non-arsenical Insecticides for Biting Insects."* Annals of Applied Biology, 1928. Vol. XV., pp. 649-658.

A convenient technique for experiments with insecticides for biting insects is described.

The silicofluorides of sodium, potassium, aluminium and calcium, used in the form of spray-fluids, showed considerable toxicity to young larvæ of several species of moths. The degree of resistance varies with different species and is greater with older larvæ. Considerable, but irregular, injury to foliage was noted, and much further work is required to establish the conditions under which these compounds could be safely used.

Foliage sprayed with extracts of certain tropical plants is extremely repellent to young larvæ. Even with high dilutions of the extracts, the foliage remained uneaten, and the larvæ eventually died of starvation.

A short review of some recent work on laboratory experiments with non-arsenical insecticides for biting insects is given.

LXXX. F. Tattersfield, R. P. Hobson and C. T. Gimingham. "*Pyrethrin I. and II. Their Insecticidal Value and Estimation in Pyrethrum ('C. cinerariæfolium') I.*" Journal of Agricultural Science, 1929. Vol. XIX., pp. 266-296.

Pyrethrin I. and II. have been isolated by the method of Staudinger and Ruzicka from the insecticidal plant Pyrethrum (*Chrysanthemum cinerariæfolium*). Both are shown to be highly toxic to the insect *A. rumicis*.

Pyrethrin I. was found to be the most toxic substance so far tested by us and it was about ten times as toxic to these insects as pyrethrin II., it is concluded that it is mainly responsible for the insecticidal value of pyrethrum.

Two micro-analytical methods of determining the pyrethrin content are described : (*a*) by means of the acids after hydrolysis; (*b*) by means of the semicarbazone.

The analytical results are obtained for a series of pyrethrum samples agreed with their observed insecticidal properties.

Comparisons of the pyrethrin contents, as estimated, with the results of direct toxicity experiments both on the pyrethrum samples and the pure pyrethrins, confirm the validity of the analytical methods.

LXXXI. F. Tattersfield and R. P. Hobson. "*Pyrethrin I. and II. Their Estimation in Pyrethrum ('Chrysanthemum cinerariæfolium') II.*" Journal of Agricultural Science, 1929. Vol. XIX., pp. 433-437.

The analytical method previously described is found applicable to flowers grown from Japanese seed. A short analytical method for evaluation is described.

(*b*) Fungus Pests and Their Control.

LXXXII. S. Dickinson. "*Experiments on the Physiology and Genetics of the Smut Fungi.-Seedling Infection.*" Proceedings of the Royal Society (B), 1927. Vol. CII., pp. 174-176.

The apparatus devised by the author (see 1925-1926 Report, Paper No. LXXII.) for isolating individual spores from a culture has made possible the present investigation. The results show that no infection of oat or barley seedlings by pure cultures of smut fungi occurs when one gender (sex) is present, but when, under similar conditions, two genders are present, 90 per cent. infection and over is obtained.

LXXXIII. S. Dickinson. "*Experiments on the Physiology and Genetics of the Smut Fungi. Cultural Characters, Part I. Their Permanence and Segregation.*" Proceedings of the Royal Society of London, 1928. Series B, Vol. CIII., pp. 547-555.

The Smut Fungus used in the experiments described is the Covered Smut of Oats (*Ustilago levis*). After isolating a chlamydospore and allowing it to germinate on a suitable medium, the first sporidium formed by each of the four segments of its promycelium was isolated, transferred to test-tube slopes, and allowed to develop in culture. Four cultures of strains were in this way obtained from one chlamydospore. This has been repeated with a number of chlamydospores of known parentage.

The strain obtained from any one of these isolated sporidia was found to differ in one or more cultural characters from the other three strains arising from the same chlamydospore. A brief description of certain of these cultural characters is given.

The segregation of these cultural characters was found to be on a 2 :2, 3 :1 and 4 :0 basis. It is deduced that this segregation may take place in either the first or the second of the " reduction divisions." So far the segregation of any one character was found to be independent of that of any other.

No conclusive evidence of somatic segregation has up to the present been obtained, the strains remaining constant during the time they have been in culture. The cytoplasm has been shown to have no determining influence on the cultural characters so far described.

LXXXIV. W. A. ROACH. " *Immunity of Potato Varieties from Attack by the Wart Disease Fungus, ' Synchytrium endobioticum ' (Schilb.) Perc.*" Annals of Applied Biology, 1927. Vol. XIV., pp. 181-192.

The present investigation is an attempt to determine, by grafting together pieces of immune and susceptible plants, whether the cause of immunity from wart disease of potatoes is carried by chemical compounds which can traverse unchanged a graft fusion layer or by those which are unable to do so.

For this purpose all the eight possible types of plants have been built up by grafting together root, shoot and tuber systems from either immune or susceptible plants.

In none of these experiments was the reaction of the tubers towards wart disease changed; hence the cause of the immunity is probably not carried by any compound which is able to traverse the plant, and the problem is thus considerably narrowed down. Examination of the proteins from immune and susceptible varieties by immuno-chemical methods is a hopeful future line of attack.

LXXXV. W. A. ROACH AND MARY D. GLYNNE. " *The Toxicity of Certain Sulphur Compounds to Synchytrium endobioticum, the Fungus causing Wart Disease of Potatoes.*" Annals of Applied Biology. 1928. Vol. XV., pp. 168-189.

The toxicities towards the winter sporangia of *Synchytrium endobioticum* of certain of the simpler sulphur compounds which are at all likely to be formed when sulphur is added to soil were tested and compared with that of sulphuric acid. Sulphuric (H_2SO_4), sulphurous (H_2SO_3), dithionic ($H_2S_2O_6$), trithionic ($H_2S_3O_6$), tetrathionic ($H_2S_4O_6$), and pentathionic ($H_2S_5O_6$) acids were toxic, and this toxicity was of the same order in each case at the same hydrogen ion concentration. Their neutral salts were non-toxic. These facts suggest that the toxicities of these acids are mainly due to their hydrogen ion concentrations.

Acidified solutions of sodium thiosulphate ($Na_2S_2O_3$), sodium hydrosulphite ($Na_2S_2O_4$) and sodium formaldehyde sulphoxylate were about ten times as toxic as sulphuric acid.

The evidence suggests that the toxicity of these acidified solutions, in excess of that accounted for by the hydrogen ion concentration, is due to the thiosulphuric acid present in each of them. In view of the instability of some of the compounds and the length of time taken to exert their toxic action on the fungus, this conclusion must be regarded as tentative.

Of the other compounds tested sodium hydroxide was found to be a little more toxic than sulphuric acid and persulphuric acid about ten times as toxic; hydrogen peroxide, calcium polysulphide and sulphuretted hydrogen were only slightly toxic.

LXXXVI. E. M. Crowther, Mary D. Glynne and W. A. Roach. "*Sulphur Treatment of Soil and the Control of Wart Disease of Potatoes in Pot Experiments.*" Annals of Applied Biology, 1927. Vol. XIV., pp. 422-427.

In a series of pot experiments on potatoes grown in an acid soil artificially infected with the wart disease fungus, treatments with sulphuric acid and various combinations of sulphur and calcium carbonate, yielding a wide range of soil reaction, gave almost complete freedom from infection when the acidity of the soil had been raised to a very high value (pH 3.4 or less).

Heavy dressings of calcium carbonate, alone or with sulphur, giving a soil reaction of pH 7.5 or more, also reduced infection.

The fact that partial and even, in one experiment, complete suppression of disease was obtained at lower acidities, where the effects on the disease was not closely related to the degree of acidity, supports the tentative conclusion already drawn from field experiments that sulphur, in controlling wart disease, does not depend entirely on its effect in raising the acidity, but has also some other mode of action. Whether this toxicity which sulphur exerts apart from its effect on the acidity can be enhanced sufficiently to be of any practical value requires further investigation.

(c) Bacterial Diseases.

LXXXVII. R. H. Stoughton. "*The Influence of Environmental Conditions on the Development of the Angular Leaf-Spot Disease of Cotton.*" Annals of Applied Biology, 1928. Vol. XV., pp. 333-341.

The serious disease of cotton caused by *Bacterium malvacearum E.F.S.*, is associated with unfavourable climatic conditions. An apparatus has been devised for controlling air temperature and humidity within a chamber. It has been found that the limiting air temperature at humidities above 80 per cent. relative saturation for secondary attack by the disease is 32° C. above which infection does not occur. At 70 per cent. relative humidity, infection is slight at 25° C. At lower humidities, no infection occurs at a temperature of 28° C.

https://doi.org/10.23637/ERADOC-1-85

LXXXVIII. R. H. Stoughton. *" A Method of Maintaining Constant Humidity in Closed Chambers."* Journal of Scientific Instruments, 1928. Vol. V., pp. 365-366.

The instrument depends for its action on the vaporisation of water from muslin covering a carbon filament resistance lamp enclosed in a tin through which a stream of air is blown, and controlled by a hair hygrostat within the chamber.

(*d*) Virus Diseases.

LXXXIX. J. Henderson Smith. *" Experiments with a Mosaic Disease of Tomato."* Annals of Applied Biology, 1928. Vol. XV., pp. 155-167.

A description is given of a mosaic disease produced in tomato by a virus, possibly identical with Johnson's Tobacco Virus 6, which differs from that of ordinary tomato mosaic in the brilliance and intensity of its leaf-symptoms, but in other respects is indistinguishable from it by the characters investigated.

The filtered juice of infected plants transmits the disease in dilutions in water up to 1 in 10,000, retains its activity for a year or more at room temperature, and withstands heating for 10 minutes at 80° C., but is inactivated at 90° C.

It is not inactivated by alcohol up to 90 per cent. The virus comes down with the precipitate, and is not destroyed when the formation of precipitate is prevented by the addition of NaOH.

Attempts at cultivation of the virus outside the living plant are described; all were unsuccessful. The methods employed in filtration, inoculation, etc., are given in detail.

XC. J. Henderson Smith. *" The Transmission of Potato Mosaic to Tomato."* Annals of Applied Biology, 1928. Vol. XV., pp. 517-528.

Inoculation by leaf-mutilation with the foliage of normal potatoes produced no disease in tomato. Nine varieties of potato were tested.

Similar inoculation with foliage of mosaic potatoes produced a characteristic disease in tomato. Five varieties of potato were used, of which three had been tested in the experiments with normal foliage.

The characters of the disease are described. It is transmissible back to potato again and to other solanaceous plants. The virus is filterable, is still infectious after high dilution of the extracted juice, and remains active on keeping for several months. It is less resistant to heat and alcohol than ordinary tobacco mosaic.

The disease resembles closely the spot-necrosis disease described by Johnson as obtained by inoculation of tobacco with foliage of normal potatoes, the chief difference being the greater resistance of the potato mosaics here described.

It is probable that there exist several strains, differing in resistance, of the virus causing mosaic in the potato.

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CROPS, SOILS AND FERTILISERS.

(*a*) CROPS.

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(*b*) SOILS.

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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 is shown in Figs. I and II for the seasons 1926-27 and 1927-28 respectively, 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 anemobiagraph.)

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 Meteorology and Soil Physics.

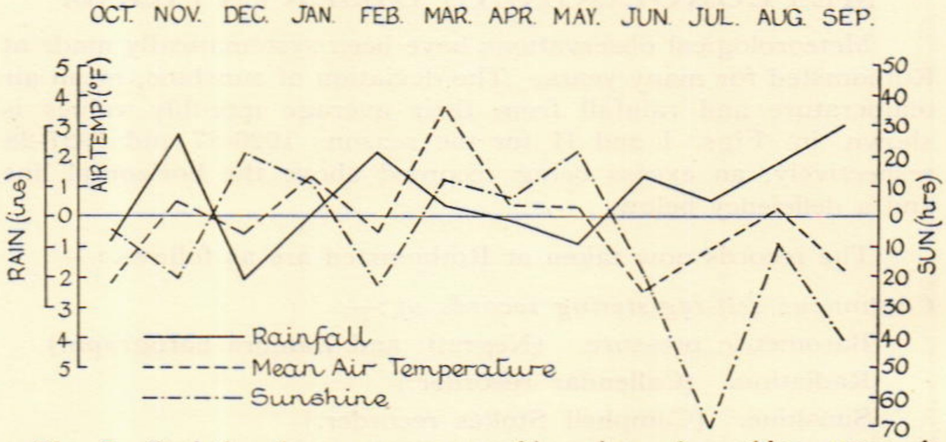

Fig. I.—Deviation from average monthly values of sunshine, mean air temperature, and rainfall—Season 1926-27.

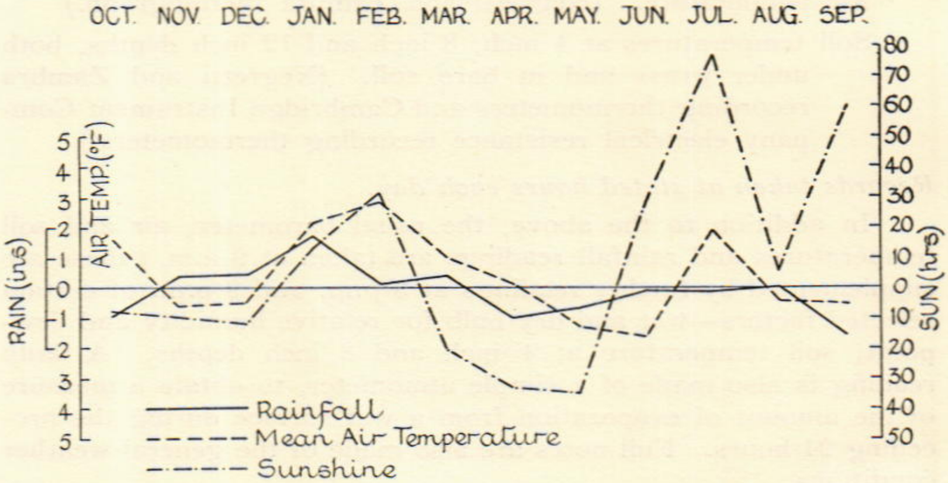

Fig. II.—Deviation from average monthly values of sunshine, mean air temperature, and rainfall—Season 1927-28.

https://doi.org/10.23637/ERADOC-1-85

THE FARM & CROP RESULTS

OCTOBER, 1926, TO SEPTEMBER, 1927.

The farm year was characterised by unusual wetness and great deficiency of sunshine. In the period under review there was 8 inches of rain above the average, and a deficiency of 119 hours of sunshine. There was no summer; the months June to September inclusive gave 6.5 inches more rainfall and 142 hours less sunshine than usual.

The year opened well. October was dry with night frosts and very favourable for the preparation of autumn seed beds. Work was well forward, the potatoes having been lifted in September. Practically all the winter corn was got in under good conditions during the month.

The rain came in November and totalled 5.32 inches for the month, which was more than twice the average figure. Ploughing was stopped and the seed beds were beaten down rather badly. Root harvest was continued under bad conditions, the crops being above the average. (Swedes 19 tons per acre.) December was mild, bright and dry, and formed a welcome change for the water-logged cereals. The favourable conditions continued till severe weather and snow in the latter half of January stopped the ploughs for a week. All cereals, except a piece of late November wheat, had wintered well. February brought hard weather and several torrential falls of rain, 3.98 inches in all, and was an unfavourable month for cultivations; and it was not until the third week in March that more genial conditions set in. Spring wheat was drilled on March 9th, and a start was made with oats and barley sowing during the month. A dry April with cool winds followed, which caused the wet furrows turned in March to dry out very harsh; seed bed preparation was difficult and the land under cereals cropped badly. Barley germinated unevenly, due to rough tilth. The drought continued in May and increased the difficulties of seed bed preparation for roots, but conditions were excellent for spring cleaning. Winter corn and spring corn where sown on good tilth looked well, but barley sown on rough tilths had suffered from drought and was poor.

Mangolds were slow to germinate and had only just chitted by the end of the month. The drought continued till June 11th, when a period of exceptional wetness set in, the month giving no less than 3.56 inches of rain, which was too late to repair the damage to the root crop. Mangolds failed on Barn Field and were replaced by swedes. Taking advantage of the first showers, sugar beet was sown on June 11th, swedes on 14th. Potatoes

G

planted on May 11th did not appear through the ridges till late in June. July was dull, cool and rather wet. A tremendous crop of charlock came up with the young sugar beet and great labour was needed to save the plant. Haymaking was carried through in catchy weather. Corn was looking well, except barley sown on rough land. Spring sown Little Joss was particularly good, but later than the other cereals. August was an exceptionally bad harvest month : the average rainfall was exceeded by 1.69 inches, and in the week ending 20th there was over 2in. of rain. The corn crop was not badly lodged, but a few fields were cut one way. Clover grew tall under the barley, swedes and potatoes looked well, but late sown Sugar Beet was disappointing and seemed to make little progress. Harvest began on August 4th with black winter oats, but no barley was cut during the month. Conditions were if anything worse in September when no less than 5.45 inches of rain fell. Barley was cut during the month and much difficulty was experienced in drying the crop owing to the great amount of clover in the sheaves. Spring wheat was cut on September 5th and carted on the 13th, yielding 16 cwt. per acre, an unusually favourable result. Four acres of barley remained uncut at the end of the month. Owing to the wet weather a certain amount of corn was put in the stack in rather damp condition. Winter wheat yielded well (22 cwt.), barley gave an average crop where the seed bed had been good, but rough sown barley only yielded 9 cwt. Oats were a good crop, averaging about 22 cwt. Potatoes (7 tons) and swedes (19 tons) were average yields for the farm, but the disappointment of the season was late sown sugar beet which only yielded 3½ tons.

OCTOBER, 1927, TO SEPTEMBER, 1928.

I. *Farm Policy.*

The principal feature of the new farm year was the continuation, on a considerable scale, of the policy begun in 1925 of laying down part of the farm to grass. The weather conditions given below were rather unfavourable for this. In consequence of this policy, an extensive programme of fencing had to be undertaken, involving the splitting of a number of the old fields. The aim was to have an arable core surrounded by grass, particularly where the farm lands were bounded by woods. The details of these developments are given in Section V below.

When the grass programme is completed in 1929 it will leave five fields (viz., Pastures, Gt. Knott, Fosters, Little Hoos and Great Harpenden) of approximately 12½ acres each, run on the rotation—wheat, hay, wheat, winter oats, and roots—each of these breaks, of course, remaining open to any modification subsequently desired. In addition to the classical fields, Long Hoos (24 acres) has been set aside for experimental purposes and has been divided into six sections run on the rotation—hay, wheat or oats, roots, wheat or oats, roots, barley. The ordnance acreage of 280 acres will then consist of: grass (123 acres), arable (87½ acres), classical experiments and exhaustion land (42½ acres), the balance being accounted for by buildings, cottages, roads and minor enclosures.

II. Weather.

The new farm year opened with the land wet, but the month comparatively dry and warm. There was little chance, however, for the sodden furrows to dry out, and this made the preparation of an autumn seed-bed difficult and unsatisfactory. Potato lifting was, naturally, under these conditions, a sticky operation, as was the lifting of the other root crops.

The land continued wet throughout the winter, but on December 15th a period of sharp frost set in (22 deg. being registered on the 19th). This gave way to heavy rain on the 22nd, which was followed by heavy snow on Christmas Day. Deep drifts formed and the farm road was closed for ten days. Severe conditions continued in January, there being 17 deg. of frost on the 18th. Thus work on the land was at a standstill for over a month, but the cap of snow saved the winter corn.

February with bright warm weather and only a slight excess of rainfall (.138in. above the 75 years' average) brought a welcome change. Drier conditions prevailed from now to the end of the season; each month had less rainfall than the average, September being no less than 1.64in. below its average of 2.43in. There was a deficit of sunshine during March, April and May, totalling 89 hours, but this was more than counterbalanced by the excess of 171 hrs. during the remaining four months.

These conditions made it difficult to secure a spring tilth, the soil drying out hard, and receiving little further rain to soften the clods. The soil in the autumn-sown fields had settled down very hard, and it was impossible to procure a tilth there for grass-seeds. The long dry spell, however, greatly favoured fallowing operations, both before sowing the roots and after removing the first crop of hay. During hay-time and harvest conditions were almost ideal.

III. Crops. (For dates, yields and other information see Table on p. 120.)

Wheat and winter oats were sown under unfavourable conditions, with the exception of Broadbalk, where a two years' fallow on the top two-fifths of the field had brought the land into excellent condition. Wheat wintered well, except for 7 acres in Gt. Knott, which would have been ploughed up but for pressure of other work; it yielded only 2½ qrs. per ac. Grey winter oats in Stackyard looked rather doubtful in February, but after a good harrowing and manuring came on well and gave an excellent crop. Black winter oats in Gt. Knott had to be ploughed up.

The tilth for spring oats and barley was, on the whole, poor, and the dry spring held them back. In the barley in Long

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Hoos there threatened to be a very heavy crop of charlock which was controlled by spraying.

Harvest was conspicuous for the absence of laid grain, except on two or three of the most heavily manured Broadbalk plots. Broadbalk yielded exceptionally well, and Stackyard oats and Pastures wheat were both very satisfactory, but the remainder of the grain crop was disappointing.

Potatoes were planted by April 21st in Gt. Harpenden. The land was in a dirty condition, but dry weather and frequent cultivation effectively cleaned it. Spraying was carried out on July 26th. There was little blight, but, although the seed was fresh from Scotland, a certain amount of Leaf Roll and Mosaic was observed. The year ended with conditions ideal for lifting the crop.

Sugar beet and swedes were grown in the same field as the potatoes. Three-tractor ploughings, with other cultivation, made a good seed-bed, and the beet was sown on May 5th. Swedes were sown from May 9th, after being dunged heavily in the drill. Both crops progressed steadily throughout the season and did well.

Mangolds which were sown on May 2nd were slow in starting because of the poor tilth, and were not thinned until June 20th, but after this went forward steadily.

The clover hay crop was good and well secured.

IV. Stock, Etc.

Thirty-two young cattle were bought in March and kept in store condition on rough grass until early summer. In August, 12 of them were sent to Woburn for box-feeding, the remainder being fattened here either inside or on the grass.

Sheep were purchased for the basic slag grazing experiment, and for this purpose 110 Scottish half-bred ewe hoggs were obtained. At the close of the experiment these sheep were retained to found a permanent ewe flock, and run with Suffolk and Hampshire rams. In September three score Masham lambs were bought to fold on rape and kale.

It was possible to increase the number of pigs this season, because a piggery was erected by the farm staff during the summer. A start has been made with building up a herd of pure Wessex Saddlebacks.

A new Dutch Barn was built alongside the old one, thereby doubling the area under cover, which is now almost 10,000 sq. ft.

V. Grass.

The following two tables give the details of the grass programme. The new divisions of the fields with their fences are shown in the map of the farm.

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TABLE I.

Field.	Area in Acres.	Sowing Date.	Nurse Crop.	Mixture.	REMARKS AND NOTES.
Little Knott	9½	19/5/25	Spring Oats	No. 9	Only 2 bush per acre oats sown and cut green 30/6/25. Wild white clover sown on bare places in 1926. Hayed 1926 and 1927.
,,	1	7/9/28	—	—	
Great Knott	5½	22/5/28	—	1	Warm dry weather after sowing killed many of the seedlings unprotected by a nurse crop, so that by the end of the farm year the plant was rather poor and gappy.
,,	10	25/4/28	6 acs. Wheat 4 acs. Spring Oats	1	In 4 strips starting from Fosters; Indigenous and commercial strains alternately. The young plant suffered from drought, but picked up after the harvest.
Fosters	3½	17/5/28	Rape	4	Rape fed off by sheep in September. A promising plant.
	2½	24/4/28	Wheat	4	Has done quite well.
West Barnfield	12½	28/8/28	—	4	Wheat stubble ploughed, harrowed, rolled before the grass was sown. Not as good as Gt. Harpenden or Sawyers. Sown rather late.
Sawyers	9½	25/4/28	Barley	1, 6, 8, 7, 4, 5	In the order given from the central road, all look well and promising. Equal to that sown under rape.
	8½	26/4/28	Barley	1	Alternate sections of indigenous and commercial mixture. A promising plant.
	4	24/8/28	—	4, 2	After fallow. Sown at right time. Very good.
	4	13/3/29	Barley	2, 3	Nearly as good as Gt. Harpenden.
Gt. Harpenden	4½	24/8/28	—	4	After clover hay and bastard fallow. Very promising, best grass on the farm.
	5	4/4/29	Barley	5	
New Zealand	7½	4/9/28	—	4	Sown in autumn on wheat stubble, which was ploughed, harrowed, and rolled before sowing. Sown too late. Very poor. Reseeded in spring. 1929.
Stackyard	8	21/4/28	Winter Oats	3, 1, 2, 4	In the order stated, strips parallel to Broadbalk drain. Seemed to be a complete failure at harvest, but soon began to fill up in a surprising manner after oats were carted.
	95½				All grass seeds were broadcast.

TABLE II.—DETAILS OF GRASS SEED MIXTURES.

Grass.	1	2	3	4	5	6	7	8	9	10
Italian Ryegrass						4	4	4		4
Perennial Ryegrass (Evergreen Indigenous)	10	9	10	16	30			5	10*	14
Cocksfoot (Late Flg. Indigenous)	8	7	8	10	10	10	6	5	8	
Timothy (Late Flg. Indigenous)	2	2	2	4		2	4	2	2	
Tall Fescue						10				
Meadow Fescue	2	2					10	5	2†	
Meadow Foxtail (Cotswold) ...		2					3	5		
Rough Stalked Meadow Grass...	2	2	2	½		1	2	1	2	3
Early Flowering Red Clover ...	1	1	1				1			
Late Flowering Red Clover (Montgomery)	2	3	3	4		3	3	4	4	
Alsike Clover						1				
Wild White Clover (Kentish) ...	1	1	1	1	1	1	1	1	1	1
Trefoil							2			
Chicory	2	2				2				
Rape										4
	30	31	27	35½	41	34	36	32	29	26

Indigenous strains only used except where otherwise indicated in Table I.

* 5 being commercial.
† In shade of wood only

WOBURN EXPERIMENTAL FARM

REPORTS FOR 1926-7 AND 1927-8,

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

SEASON 1926-7.

This season was the third unfavourable one in succession. A wet November delayed the early growth of wheat, and all crops were affected by the absence of sunshine and warmth after May, and by the wet August and September; ripening of cereal crops was unsatisfactory and harvest was badly delayed. The first cut of hay was poor, while the second cut was ruined by the wet. Sowing of the root crops was ruined by weather, and the yields were below average.

SEASON 1927-8.

This season was distinctly better. Autumn operations were concluded without difficulty, and wheat came up well. After Christmas, cold and dull weather persisted until May, and sowing of spring crops was delayed. However, the warmer weather of the next two months was a great help to all crops, except potatoes which suffered through drought, and grass that had suffered from the earlier dull weather. Harvesting was carried through without difficulty.

RAINFALL.

	1926–7. Inches.	No. of days on which rain fell.	1927–8. Inches.	No. of days on which rain fell.
October	2.22	9	1.20	17
November	3.39	20	2.17	18
December	0.40	3	2.52	14
January	2.15	13	3.69	24
February	2.87	13	1.45	12
March	2.09	19	1.56	18
April	1.35	10	1.11	16
May	0.70	9	1.43	14
June	3.27	18	2.39	17
July	1.79	11	2.58	10
August	3.19	20	2.77	20
September	4.37	17	0.70	10
	27.79	162	23.57	190

FIELD EXPERIMENTS.

1.—CONTINUOUS GROWING OF WHEAT AND BARLEY (STACKYARD FIELD).

As stated in the Report for 1925-26, it was decided to fallow these plots, which had become infested with weeds. Intensive cleaning operations have been in progress in the past two seasons, including hand-digging to remove twitch and bind weed. The dominant weeds—coltsfoot and mayweed on the wheat plots, and spurrey on the barley plots—were attacked by repeated ploughing and harrowing, but the wet season of 1926-27 enabled many of them to root afresh after the operations. Better progress was made in 1927-28, especially on the wheat plots, and at the end of the season all the plots were clean. Wheat and barley will therefore be sown for the 1928-29 season, but no manures will be given, so that the effect of two years fallowing, coupled with the withholding of manures for three years, may be ascertained.

The average yields for the fifty years during which the experiments ran before the fallowing operations, are given in Tables I and II.

2.—ROTATION EXPERIMENTS.

The Unexhausted Value of Cake and Corn (Stackyard Field)

(a) Series C.

1927.—BARLEY.

The details of the preparation of the land for barley by folding the previous root-crop with sheep were as follows :—

Corn-fed Plot.

Swedes, 13 t. 18 cwt. per acre, plus oats equivalent to 14.27 lb. nitrogen per acre.

Cake-fed Plot.

Swedes, 13 t. per acre, plus linseed and cotton cake equivalent to 37.7 lb. nitrogen per acre.

Barley was sown three weeks after feeding was finished. The yields were :—

Barley after Swedes, Produce per Acre.

Plot.		Head Corn.		Tail Corn Weight.	Straw, Chaff, etc.
		Bushels.	Weight per Bushel.		
			lb.	lb.	cwt.
1	Corn-fed	16.8	42.5	39.5	11.2
2	Cake-fed	18.1	44.0	49.0	12.6

In spite of the increased amounts of nitrogen given, the extra yield on the cake-fed plot (1.3 bush. corn and 1.4 cwt. straw) is no greater than on the corresponding area of Series D in 1926, when no cake or corn was given (Report 1925-26, p. 103).

https://doi.org/10.23637/ERADOC-1-85

TABLE I.

CONTINUOUS GROWING OF WHEAT. Stackyard Field, 1877-1926

Plot.	Manures Applied Annually per acre.	Average Produce of Dressed Corn per acre.				Average Weight per bushel.				Average Produce of Straw, Chaff, etc., per acre.			
		20 years, 1877–96. cwt.	10 years, 1897–1906. cwt.	10 years, 1907–16. cwt.	10 years, 1917–26. cwt.	20 years, 1877–96. lb.	10 years, 1897–1906. lb.	10 years, 1907–16. lb.	10 years, 1917–26. lb.	20 years, 1877–96. cwt.	10 years, 1897–1906. cwt.	10 years, 1907–16. cwt.	10 years, 1917–26. cwt
1	Unmanured	7·62	4·85	5·27	3·64	57·6	60·3	60·1	58·4	15·01	8·96	8·60	6·80
2a	[1]Sulphate of Ammonia (= 50 lb. Ammonia till 1906, 25 lb. since)	12·29	5·01	0·28	0·30	57·3	59·8[7]	60·0[9]	58·7[10]	22·40	7·62	1·54	1·56
2aa	As 2a, with 5 cwt. lime, Jan. 1905; repeated 1909, 1910 and 1911	—	—	6·06	3·75	—	—	60·3[11]	58·9[12]	—	—	9·86	8·02
2b	As 2a, with 2 tons lime, Dec. 1897...	—	9·38[5]	8·89	4·27	—	59·6[5]	60·2	59·0	—	14·06[5]	12·34	7·95
2bb	As 2b, with further 2 tons lime, Jan. 1905	—	—	7·50	4·77	—	—	59·3	59·0	—	—	12·94	8·53
3a	Nitrate of Soda (= 50 lb. Ammonia)	11·75	9·47	9·93	8·09	55·2	57·2	57·1	57·3	23·72	18·33	18·65	14·57
3b	Nitrate of Soda (= 25 lb. Ammonia) since 1907 only	—	—	8·50	7·08	—	—	57·7	58·1	—	—	15·02	12·77
4	[2]Mineral Manures	7·82	4·68	4·84	4·42	57·8	60·6	60·0	58·1	15·60	8·72	8·48	8·63
5a	Mineral Manures and Sulphate of Ammonia as 2a ...	15·86	13·89	8·86	5·06	58·7	61·9	59·8	58·5[12]	29·03	19·79	13·56	9·98
5b	As 5a with 1 ton lime, Jan. 1905...	—	—	12·03	7·37	—	—	60·5	59·0	—	—	17·11	13·02
6	Mineral Manures and Nitrate of Soda (= 50 lb. Ammonia till 1906; 25 lb. since) ...	16·15	13·29	9·73	8·58	57·8	59·7	58·6	58·0	31·38	22·61	17·19	14·78
7	Unmanured	8·14	6·17	5·79	4·05	57·0	61·1	59·9	58·7	15·42	9·88	8·85	6·86
8a	Mineral Manures: Sulphate of Ammonia (= 100 lb. Ammonia till 1906; 50 lb. since) in alternate years, beginning with 1883 ...	15·87[6]	10·17	2·74	2·10	59·1[6]	60·8[8]	59·0[13]	60·1[14]	28·62[6]	15·88	5·41	4·39
8aa	As 8a, with 10 cwt. lime, Jan. 1905, repeated Jan. 1918 ...	—	—	9·94	5·30	—	—	59·5	59·6	—	—	15·73	10·62
8b	Mineral Manures: Sulphate of Ammonia as 8a, yearly till 1882, omitted in 1883 and alternate years since ...	15·81[6]	12·09	4·96	1·71	59·2[6]	61·7	60·0[15]	59·7[16]	27·66[6]	18·04	4·55	3·35

https://doi.org/10.23637/ERADOC-1-85

ERRATA: For 8a, aa, b and bb, and 9a and b, read as follows:

	Years when												
8a	Sulph. Ammonia applied {8a and b	20·02[6]	13·33	2·74	2·10	59·3[6]	61·7	59·0[13]	60·1[14]	35·53[6]	19·62	5·41	4·39
8aa	Sulph. Ammonia applied {8aa and bb	—	—	9·94	5·30	—	—	59·5	59·6	—	—	15·73	10·62
8b	Sulph. Ammonia omitted {8a and b	12·25[6]	8·94	2·45	1·71	59·1[6]	60·8[8]	60·0[15]	59·7[16]	20·76[6]	14·29	4·55	3·35
8bb	Sulph. Ammonia omitted {8aa and bb	—	—	7·60	4·61	—	—	60·4	58·8[12]	—	—	11·69	7·75
9a	Nitrate of Soda applied ...	17·32[6]	16·49	10·17	8·22	56·9[6]	59·8	58·8	59·0	36·85[6]	29·45	19·28	16·09
9b	Nitrate of Soda omitted ...	8·59[6]	6·73	5·82	4·62	58·6[6]	60·9	60·0	58·8	15·31[6]	11·53	9·80	8·29

WHEAT

10a	Unmanured 1882–1906[3] (except rape cake in 1889 as 10b) Superphosphate 3 cwt., Nitrate of Soda (= 25 lb. Ammonia) 1907–1926 ...	9·07[6]	7·18	9·72	8·28	58·1[6]	61·1	58·9	58·2	16·17[6]	11·10	16·05	13·96
10b	Farmyard Manure (= 100 lb. Ammonia) 1877–87, unmanured 1888, rape cake 1889–1906 (= 50 lb. Ammonia in 1889, 100 lb. thereafter) rape dust (= 25 lb. Ammonia) 1907–26 ...	—	15·01	10·64	6·79	—	61·0	60·8	59·3	—	25·56	16·48	11·69
11a	Unmanured 1882–1906.[4] Sulphate of Potash 1 cwt., Nitrate of Soda (= 25 lb. Ammonia) 1907–26 ...	9·71[6]	8·01	8·65	7·15	58·4[6]	61·2	59·1	58·5	17·00[6]	12·34	15·33	13·97
11b	Farmyard Manure (= 200 lb. Ammonia till 1906, 100 lb. since)	14·27	13·46	11·03	9·54	58·7	60·7	59·7	58·6	26·55	24·50	21·31	19·01

[1] Till 1907 Ammonia Salts (equal weights of Sulphate and Muriate of Ammonia) were applied; since 1907 Sulphate of Ammonia only has been used.

[2] Minerals for first 30 years were:—3½ cwt. Superphosphate, 200 lb. Sulphate of Potash, 100 lb. Sulphate of Soda, 100 lb. Sulphate of Magnesia, per acre. Since 1906, 3 cwt. Superphosphate and ½ cwt. Sulphate of Potash only.

[3] Previous to 1882 Farmyard Manure as 10b.

[4] Previous to 1882 Farmyard Manure as 11b.

[5] 9 years only, 1898–1906.

[6] 15 years only, 1882–1896.

[7] Omitting 1904 and 1905 when there was no crop.

[8] Omitting 1904 when there was no crop.

[9] 1907 and 1911 only.

[10] 1917, 1920 and 1922 only.

[11] Omitting 1909.

[12] Omitting 1925.

[13] Omitting 1914, 1915, 1916.

[14] Omitting 1924 and 1926.

[15] Omitting 1913, 1914, 1916.

[16] Omitting 1924, 1925, 1926.

https://doi.org/10.23637/ERADOC-1-85

TABLE II.

CONTINUOUS GROWING OF BARLEY. Stackyard Field, 1877-1926

Plot.	Manures Applied Annually per acre.	Average Produce of Dressed Corn per acre.				Average Weight per bushel.				Average Produce of Straw, Chaff, etc., per acre.			
		20 years, 1877–96. cwt.	10 years, 1897–1906. cwt.	10 years, 1907–16. cwt.	10 years, 1917–26. cwt.	20 years, 1877–96. lb.	10 years, 1897–1906. lb.	10 years, 1907–16. lb	10 years, 1917–26. lb.	20 years, 1877–96. cwt.	10 years, 1897–1906. cwt.	10 years, 1907–16. cwt.	10 years, 1917–26. cwt.
1	Unmanured	10·12	5·63	4·80	3·88	51·6	52·4	50·2	50·2	12·77	6·85	7·78	6·91
2a	[1]Sulphate of Ammonia (= 50 lb. Ammonia till 1906, 25 lb. since)	15·61	1·92	0·18	0·75	51·9	53·0[7]	48·0[8]	51·4[9]	18·91	3·47	0·41	1·30
2aa	As 2a, with 5 cwt. lime, Mar. 1905; repeated 1909, 1910 and 1912, and 10 cwt. lime in 1923	—	—	3·38	2·53	—	—	51·1[10]	51·2	—	—	6·35	5·60
2b	As 2a, with 2 tons lime, Dec. 1897, repeated 1912 ...	—	10·36[5]	6·93	4·04	—	52·4[5]	50·9	50·9	—	11·34[5]	10·36	7·45
2bb	As 2b, with further 2 tons lime, Mar. 1905	—	—	7·04	3·96	—	—	51·6	50·1	—	—	9·53	7·34
3a	Nitrate of Soda (= 50 lb. Ammonia)	16·40	11·40	7·40	5·33	51·4	51·8	50·4	50·3	21·49	13·97	12·95	9·18
3b	Nitrate of Soda (= 25 lb. Ammonia) since 1907 only ...	—	—	6·69	3·99	—	—	49·8	49·8	—	—	10·36	7·25
4a	[2]Mineral Manures	10·37	7·93	6·07	4·67	51·7	53·1	50·4	50·5	12·13	8·60	9·26	7·20
4b	As 4a, with 1 ton lime, Mar. 1915...	—	—	—	5·33	—	—	—	50·4	—	—	—	8·26
5a	Mineral Manures and Sulphate of Ammonia as 2a ...	18·63	3·52	1·37	2·38	53·2	53·1	50·9[11]	51·2[12]	22·51	5·27	3·16	4·24
5aa	As 5a, with 1 ton lime, Mar. 1905, repeated 1916 ...	—	—	9·66	7·30	—	—	52·2	50·7	—	—	14·46	10·69
5b	As 5a, with 2 tons lime, Dec. 1897, repeated 1912 ...	—	16·85[5]	9·97	6·19	—	54·2[5]	51·5	50·4	—	19·18[5]	14·20	8·91
6	Mineral Manures and Nitrate of Soda (= 50 lb. Ammonia till 1906; 25 lb. since) ...	20·51	17·01	9·52	7·70	52·7	53·5	50·6	49·8	27·34	21·17	14·43	10·91
7	Unmanured	9·37	6·50	4·07	3·34	51·1	52·4	50·4	50·4	11·59	7·11	6·44	5·76
8a	Mineral Manures: Sulphate of Ammonia (= 100 lb. Ammonia till 1906; 50 lb. since) in alternate years, beginning with 1883	17·11[6]	6·66	1·60	0·85	52·7[6]	53·8	51·2[13]	50·1[14]	21·24[6]	7·49	2·35	1·27

Years when

8a	Sulph. Ammonia applied	8a and b	21·14[6]	7·29	1·60	0·85	52·5[6]	53·9	51·2[13]	50·1[14]	28·09[6]	9·13	2·35	1·27
8aa		8aa and bb	—	18·87[5]	11·05	7·29	—	54·1[5]	51·4	51·4	—	22·19[5]	15·58	10·92
8b	Sulph. Ammonia omitted	8a and b	14·73[6]	6·41	0·72	0·46	53·1[6]	53·9	51·3[15]	51·0[16]	17·24[6]	7·44	1·26	0·94
8bb		8aa and bb	—	14·11[5]	7·36	5·21	—	54·3[5]	51·3	51·1	—	14·59[5]	10·63	8·51
9a	Nitrate of Soda applied ...		23·18[6]	21·00	12·26	9·23	51·8[6]	53·3	50·9	50·4	34·70[6]	26·92	19·26	13·67
9b	Nitrate of Soda omitted ...		14·82[6]	11·53	7·81	6·19	53·3[6]	53·7	50·6	50·8	16·75[6]	12·84	11·32	9·48

BARLEY

	alternate years, beginning with 1883	18·82[6]	16·27	12·26	9·23	52·7[6]	53·5	50·9	50·4	24·91[6]	18·91	19·26	13·67
9b	Mineral Manures: Nitrate of Soda as 9a, yearly till 1882, omitted in 1883 and alternate years since	19·17[6]	16·27	7·81	6·19	52·5[6]	53·5	50·6	50·8	26·55[6]	20·85	11·32	9·48
10a	Unmanured 1882–1906[3] (except rape cake in 1889 as 10b), Superphosphate 3cwt., Nitrate of Soda (= 25 lb. Ammonia) 1907–1926 ...	12·36[6]	8·21	8·80	6·76	51·9[6]	53·2	50·6	50·4	14·89[6]	9·25	13·72	10·17
10b	Farmyard Manure (= 100 lb. Ammonia) 1877–87, unmanured 1888, rape cake 1889–1906 (= 50 lb. Ammonia in 1889, 100 lb. thereafter), rape dust (= 25 lb. Ammonia) 1907–26 ...	—	16·41	8·44	4·08	—	53·1	51·2	51·3	—	20·12	11·84	7·29
11a	Unmanured 1882–1906.[4] Sulphate of Potash 1 cwt., Nitrate of Soda (= 25 lb. Ammonia) 1907–26 ...	15·50[6]	10·78	11·13	8·31	52·6[6]	53·3	50·3	50·7	18·39[6]	12·33	17·26	11·98
11b	Farmyard Manure (= 200 lb. Ammonia till 1906, 100 lb. since)	18·69	18·09	14·89	12·26	53·1	53·8	51·6	51·3	22·45	21·71	20·52	17·79

[1] Till 1907 Ammonia Salts (equal weights of Sulphate and Muriate of Ammonia) were applied; since 1907 Sulphate of Ammonia only has been used.
[2] Minerals for first 30 years were:—3½ cwt. Superphosphate, 200 lb. Sulphate of Potash, 100 lb. Sulphate of Soda, 100 lb. Sulphate of Magnesia, per acre. Since 1906, 3 cwt. Superphosphate and ½ cwt. Sulphate of Potash only.
[3] Previous to 1882 Farmyard Manure as 10b.
[4] Previous to 1882 Farmyard Manure as 11b.
[5] 9 years only, 1898–1906.
[6] 15 years only, 1882–1896.
[7] Omitting 1905 and 1906.
[8] 1912 only.
[9] 1919, 1920, 1921, 1922 and 1926 only.
[10] Omitting 1908.
[11] 1907, 1909, 1910, 1912 and 1916 only.
[12] Omitting 1918, 1924 and 1925.
[13] 1907, 1909, 1910 and 1912 only.
[14] Omitting 1923, 1924 and 1925.
[15] 1907, 1909 and 1912 only.
[16] 1919, 1920, 1921, 1922 and 1926 only.

1928.—CLOVER.

Red clover was sown in the barley crop of 1927, and gave a good plant. In the middle of March it became patchy and the parasitic eelworm *Tylenchus dipsaci* was found to be present. Although the crop improved later, it was patchy at harvest, and no reliance can be placed on the difference recorded on the two plots :—

	Produce per acre of Red Clover.
	cwt.
1. (Cake plot)	33.4
2. (Corn plot)	59.6

The aftermath, although regular, was of small amount, and, owing to the lateness of the season, it was ploughed in.

(b) Series D.

1927.—CLOVERS.

Mixed clovers were sown in the barley crop of 1926 : red clover 7 lb., alsike 3 lb., trefoil 3 lb. per acre. Owing to the season the crop was cut late. The actual yields of hay per acre were :—

Corn-fed plot, 60.7 cwt. ; cake-fed plot, 42.5 cwt.

The cake-fed plot was damaged by rabbits and its yield was appreciably reduced.

Owing to the late season no second cut was taken.

1928.—WHEAT.

" Little Joss " wheat made satisfactory early growth, but began to look yellow in May. With warmer weather it recovered somewhat. The yields were as follows :—

Wheat after Clovers, Produce per Acre.

Plot.		Head Corn.		Tail Corn Weight.	Straw, Chaff, etc.
		Bushels.	Weight per Bushel.		
			lb.	lb.	cwt.
1	Corn-fed	17.6	59.7	116	15.2
2	Cake-fed	18.6	60.4	139	17.2

It should be noted that the swedes failed in 1925 and 1921 ; hence there has been no corn or cake-feeding on these plots since 1916.

3.—GREEN MANURING EXPERIMENTS.

(a) Stackyard Field. Series A.

Upper Half.

1927.—WHEAT.

Following the green crops of 1926, " Little Joss " wheat was sown, and up to April looked very well. Then the usual signs of failure began to appear, and a considerable growth of poppies was also noted. The yields were very poor, as has been the case for years past :—

Wheat after Green Crops, Produce per Acre.

Plot.		Head Corn.		Tail Corn Weight.	Straw, Chaff, etc.
		Bushels.	Weight per Bushel.		
			lb.	lb.	cwt.
1	After Tares fed off ...	4.9	58.5	24	11.4
2	After Tares fed off, limed 1923 ...	2.4	58.5	18	10.7
3	After Mustard fed off	6.8	58.0	24	9.2
4	After Mustard fed off, limed 1923 ...	2.0	58.0	14	6.9

The application of lime has again produced no improvement; if anything the reverse. The problem of accounting for these poor yields of wheat from a plant that always looks exceedingly promising in its early stages, and which follows an excellent growth of tares or mustard, is one that still defies solution.

1928.—GREEN CROPS FED OFF BY SHEEP.

After the wheat harvest, tares and mustard were sown as usual, and mineral manures (super 3 cwt. sulphate of potash 1 cwt.) were applied to both plots. A good crop of each resulted, which was fed off by sheep that also received 3 cwt. of linseed and cotton cake per acre. The land has been ploughed and sown to wheat.

Lower Half.

1927.—GREEN CROPS FED OFF BY SHEEP.

Tares and wheat were sown, mineral manures (super. 3 cwt., sulphate of potash 1 cwt.) being also applied. Excellent crops were obtained. These were fed off with sheep that also consumed 3 cwt. of linseed and cotton cake per acre.

1928.—WHEAT.

During the preparation of the land after the green-crops a good deal of twitch was removed. The wheat came up well and, up to February, was in excellent condition. After this it began to fall off as usual. By July the appearance was very poor, and but low yields were obtained :—

Wheat after Green Crops, Produce per Acre.

Plot.		Head Corn. Bushels.	Head Corn. Weight per Bushel.	Tail Corn Weight.	Straw, Chaff, etc.
			lb.	lb.	cwt.
1	After Tares fed off ...	7.1	58.7	41	9.1
1a	After Tares fed off, limed 1924 ...	7.4	58.7	51	9.8
2	After Mustard fed off	7.9	58.9	32	9.7
2a	After Mustard fed off, limed 1924 ...	3.7	60.0	24.5	5.5.

These results urgently call for enquiry. The low yields follow the application of mineral manures in the previous season, when an excellent green crop was obtained, and the land was further enriched by the 3 cwt. per acre of cake received by the sheep folded on the tares and mustard. A further point at present inexplicable is the depressing effect of lime on the wheat grown on the mustard plot.

(b) Lansome Field.

1927.—WHEAT.

Little Joss wheat followed the green crops of 1926 that had been ploughed in. At first the plant looked weaker on the mustard plots, but improved later. In the early months of 1927 difference was observed between the old plots begun in 1892 and the new series commenced in 1922, the former being much the worse. By June the growth of mayweed on the old plots was so great that, to prevent it from seeding, it was decided to cut this area at once, and to plough the land. Mayweed was less serious on the new plots, and was pulled out by hand, but, even on this area, the yields were almost too small to record; in all cases they were less than 1 bushel per acre :—

Wheat after Green-Crops Ploughed in, Produce per Acre.

	Plot.	Corn.	Straw, Chaff, etc.
Old Plots	1. After Mustard ploughed in 2. After Tares ploughed in	plots harvested green ; no yields taken	
		lb.	cwt.
New Plots	3. After Mustard ploughed in	8	2.4
	4. After Tares ploughed in ...	24	2.6
	5. Control (no green-crop) ...	20	4.4

1928.—GREEN CROPS.

Mustard and tares were drilled and mineral manures (super. 3 cwt. and sulphate of potash 1 cwt. per acre) applied. A fair crop was obtained and the mayweed seemed somewhat reduced.

The crop was ploughed under in mid-July and a second crop sown. These did not attain much size up to the time they were ploughed under in preparation for the succeeding wheat crop. Mayweed was still very noticeable, especially on the old plots.

4.—THE RELATIVE VALUES OF LIME AND CHALK FOR LIMING PURPOSES. STACKYARD FIELD. SERIES B.

1927.—OATS.

In the preceding year seeds were grown on one half of the area and lucerne on the other half (Report 1925-26 pp. 109-110). The whole area was ploughed in the winter and oats were sown. A good growth was secured, that on the seeds area being the better. The figures in the following table refer to this area only :—

Lime and Chalk Experiment—Stackyard Field—Series B.
Oats, 1927, Produce per Acre.

Plot.	Applications per acre in 1919.	Head Corn Bushels.*	Tail Corn Weight.	Straw, Chaff, etc.
			lb.	cwt.
1	No Chalk	25.4	132	13.1
2	Chalk=10 cwt. lime	33.9	114	17.1
3	Chalk= 1 ton lime	33.4	156	15.8
4	Chalk= 2 tons lime	37.2	192	19.0
5	Chalk= 3 tons lime	35.6	180	16.3
6	Chalk= 4 tons lime	32.1	156	16.8
7	No Lime	31.6	216	17.9
8	Lime 10 cwt.	28.3	222	16.8
9	Lime 1 ton	29.4	228	16.6
10	Lime 2 tons	34.6	252	18.9
11	Lime 3 tons	27.0	180	16.4
12	Lime 4 tons	33.2	104	18.8

* Weight per bushel taken on whole produce=33 lb.

Subject to the restriction that the duplicate control plots (Nos. 1 and 7) differ in yield, it appears that, on the average, the chalk series gave 1 cwt. more corn, but less straw, than the lime series. Hence, over the duration of this experiment there has been little to choose between lime and the equivalent quantity of chalk; further, no additional benefit has been obtained from dressings of lime (or its equivalent in chalk) exceeding 2 tons per acre.

This experiment has now been discontinued.

5. MANURING AND LIMING OF GRASS LAND—BROAD MEAD.

Since 1901 manurial experiments on grass land have been conducted in Broad Mead. As a rule the land has been alternatively grazed and hayed. Since 1925 the field has been grazed each year. In addition to these manurial experiments there were two other series of experiments in this field, the one being on different varieties of lime (Buxton, chalk, magnesian, lias, and oolite limes), the other on different forms of lime (lump lime, ground lime, ground limestone, ground chalk). These series received nothing except the lime and the droppings of the grazing animals.

Owing to a re-arrangement of the programme of work, it has been decided to give up the two last sets of experiments (on liming) and to retain only the original manurial series of 1901, less one unimportant plot.

It is appropriate, therefore, to summarise the results of the two sets of experiments on liming which are now to be discontinued. These have shown that the use of lime of any kind or form has been beneficial, although, as shown in the manurial experiment (see (c) below), the addition of fertilisers produces a further improvement.

(a) Varieties of Lime.

The experiment began in 1910; three applications at 2 tons per acre were given during the period 1910-1928. All the different varieties of lime have improved the pasture, in the order—chalk, Buxton, lias and oolite, magnesium.—The unmanured plot remained rough and unattractive to stock; on the limed plots the effect appeared to be an improvement in quality of herbage rather than a change in botanical composition.

(b) Forms of Lime.

This series began in December, 1924. A single application was given at the following rates:—Lump lime, ground lime, 2 tons per acre; ground limestone, and ground chalk, 4 tons per acre. Up to the time of discontinuing the experiment, benefit had been obtained only from the two first materials.

(c) Manurial Experiment.

As stated above, this experiment is being continued as a demonstration of the advantage of lime with mineral manures on grass land. Lime at 2 tons per acre has been applied to one plot six times in the full period of 1901-1928. Little effect was seen until 1910, when 3 cwt. of super and 1 cwt. of sulphate of potash were put on, similar dressings being given also in 1913 and 1920. This plot, although giving a small hay yield, is now much the best for grazing. Next in order are the two plots receiving basic slag and super, with the addition of sulphate of potash in each case. As would be expected, the proportion of clover in the herbage has increased. The biggest hay yield comes from the farmyard manure plot, although its quality is inferior. Finally, the unmanured plot remains rough and neglected by stock, and provides an excellent contrast to the other plots.

https://doi.org/10.23637/ERADOC-1-85

REPLICATED EXPERIMENTS.

Below is given a list of the replicated experiments done at Woburn during 1927 and 1928, together with the page numbers on which the tables of results will be found. One experiment of 1926 which did not appear in the last Report is included.

Year.	Crop.	Nature of Experiment.	Resutls.
1926	Potatoes ...	Nitrogenous Fertilisers: Sulphate of Ammonia and Cyanamide, each in Single and Double Dressings ...	See p. 155
1927	Potatoes ...	Effect of Superphosphate	See p. 156
1927	Potatoes ...	Nitrogenous Fertilisers: Sulphate of Ammonia, Urea and Cyanamide, each in Single and Double Dressings	See p. 157
1927	Sugar Beet ...	(*a*) Comparison of Nitrogenous Fertilisers: Sulphate and Muriate of Ammonia and Cyanamide: (*b*) Preparation of Seed Bed	See p. 160
1928	Barley ...	Effect of Fertilisers on yield and quality	See p. 154
1928	Potatoes ...	Nitrogenous Fertilisers: Sulphate of Ammonia and Cyanamide, each with and without Nitrate of Soda	See p. 158
		Nitrophoska and Compound " B " ...	
1928	Potatoes ...	Effect of Superphosphate	See p. 156
1928	Sugar Beet ...	Nitrogenous Fertilisers: Sulphate of ammonia and Muriate of ammonia, each applied with seed. Nitrochalk as top-dressing	See p. 162
		Potassic Fertilisers: Muriate of Potash, Potash Manure Salts... ...	
		Nitrophoska	
1927 and 1928	Lucerne ...	Effect of Inoculation	See p. 164

OTHER EXPERIMENTS.

A number of smaller experiments were also undertaken, as follows :—

Year.	Crop.	Nature of Experiment.	Results.
1926	Mangolds ...	Effect of Ammonia Salts and Potash	See p. 164
1926	Potatoes ...	Effect of Ammonia Salts and Potash	See p. 164
1927	Mangolds ...	Top-dressing Experiment: Sulphate of Ammonia, Nitrate of Soda, Common Salt	See p. 164

https://doi.org/10.23637/ERADOC-1-85

WOBURN EXPERIMENTAL STATION

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, 1927

Field.	Crop.	Variety.	Sowing began.	Sowing finished.	Cutting began.	Carting began.	Carting finished.	Yield per Acre.
Stackfield Field—								
Permanent Wheat...	Fallow ...	... ...	... ...	... ...	... ...	... ...	... ...	...
Permanent Barley...	Fallow ...	... ...	... ...	... ...	... ...	... ...	... ...	...
Series A (*a*) ...	Green Crops ...	Tares	April 26, '27	April 26, '27	Sept. 8, '27 (fed off)	... ...	... ...	...
		Mustard	June 3, '27	June 3, '27	Aug. 27, '27 (fed off)	... ...	Sept. 7, '27	...
Series A (*b*)... ...	Wheat ...	Little Joss ...	Oct. 21, '26	Oct. 21, '26	Aug. 30, '27	Sept. 19, '27	Sept. 19, '27	2¼ cwt.
Series B	Spring Oats ...	Abundance ...	April 20, '27	April 20, '27	Aug. 30, '27	Sept. 12, '27	Sept. 19, '27	11 cwt.
Series C	Barley ...	Plumage Archer ...	Mar. 29, '27	Mar. 29, '27	Sept. 13, '27	Sept. 21, '27	Sept. 23, '27	7¼ cwt.
Series D	Clover ...	Mixed Seed ...	May 27, '26	May 27, '26	July 26, '27	Aug. 3, '27	Aug. 3, '27	50 cwt.
Butt Close	Sugar Beet ...	Dutch	June 9, '27	June 16, '27	... ...	Nov. 25, '27	Jan. 13, '28	3 tons
	Potatoes ...	Arran Comrade ...	June 25, '27	June 25, '27	... ...	Oct. 27, '27	Nov. 3, '27	4 tons
	Swedes ...	... ...	July 9, '27	July 9, '27	... ...	... ...	... ...	fed off.
Butt Furlong	Wheat ...	Little Joss ...	Oct. 20, '26	Oct 20, '26	Sept. 2, '27	Sept. 9, '27	Sept. 19, '27	9 bush.
	Potatoes ...	King Edward ...	May 25, '27	May 25, '27	... ...	Oct. 19, '27	Nov. 3, '27	4 tons
Lansome Field ...	Wheat ...	Little Joss ...	Oct. 26, '26	Oct 26, '26	Sept. 1, '27	Sept. 20, '27	Sept. 20, '27	24 lbs.
	Winter Oats	Grey and Black ...	Nov. 10, '26	Nov. 10, '26	Aug. 5, '27	Sept. 1, '27	Sept. 1, '27	32 bush.
	Potatoes ...	Eclipse, Majestic, King Edward.	May 10, '27	May 23, '27	... ...	Oct. 3, '27	Oct. 18, '27	8 tons (E. & M.) 6¾ tons (K.E.)
Mill Close	Lucerne ...	... ...	July 13, '27	July 13, '27	Oct. 13, '27	Oct. 21, '27	Oct. 21, '27	...
Road Piece	Mangolds ...	Yellow Globe ...	May 17, '27	May 26, '27	... ...	Nov. 6, '27	Nov. 23, '27	17 tons
	Spring Oats ...	Abundance ...	April 21, '27	April 21, '27	Aug. 29, '27	Sept. 12, '27	Sept. 12, '27	12 cwt.
	Seeds ...	... ...	May 21, '26	May 21, '26	July 29, '27	Aug. 11, '27	Aug. 11, '27	35 cwt.
Great Hill	Seeds ...	... ...	May 24, '26	May 24, '26	Aug. 4, '27	Aug. 17, '27	... ...	...
Warren Field ...	Wheat ...	Little Joss ...	Dec. 14, '26	Dec. 14, '26	Aug. 24, '27	Sept. 5, '27	Sept. 5, '27	18 cwt.
	Winter Beans	... ...	Nov. 11, '26	Nov. 16, '26	Aug. 23, '27	Sept. 13, '27	Sept. 13, '27	8 bush.

WOBURN EXPERIMENTAL STATION

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, 1928

Field.	Crop.	Variety.	Sowing began.	Sowing finished.	Cutting began.	Carting began.	Carting finished.	Yield per Acre.
Stackyard Field—								
Permanent Wheat...	Fallow ...	... ...	... ...	... ...	... ...	... ...	... ...	...
Permanent Barley...	Fallow ...	... ...	... ...	... ...	... ...	... ...	... ...	...
Series A	Wheat ...	Little Joss ...	Nov. 1, '27	Nov. 1, '27	Aug. 27, '28	Sept. 4, '28	Sept. 4, '28	7½ bush.
Series B	Potatoes ...	Majestic and Ally...	May 5, '28	May 10, '28	... ...	Oct. 12, '28	Oct. 13, '28	12 tons
Series C	Clover ...	Red Clover ...	May 28, '27	May 28, '27	July 3, '28	July 9, '28	July 9, '28	23¼ cwt. hay (one crop only)
Series D	Wheat ...	Little Joss ...	Oct. 29, '27	Nov. 6, '27	Aug. 27, '28	Sept. 3, '28	Sept. 3, '28	20½ bush.
Butt Close	Barley ...	Chevalier Type ...	Mar. 15, '28	Mar. 17, '28	Aug. 9, '28	Aug. 30, '28	Sept. 3, '28	18 cwt.
Butt Furlong ...	Sugar Beet ...	Dippe	May 18, '28	May 18, '28	... ...	Nov. 3, '28	Nov. 19, '28	10 tons (washed)
	Potatoes ...	King Edward ...	May 14, '28	May 15, '28	Oct. 9, '28	Oct. 9, '28	Oct. 10, '28	4½ tons
	Swedes ...	... ...	June 4, '28	June 4, '28	... ...	Oct. 15, '28	... ...	10 tons
Lansome Field ...	Seeds ...	... ...	June 1, '27	June 1, '27	June 18, '28	June 28, '28	June 29, '28	40 cwt.
	Barley ...	Chevalier Type ...	Mar. 14, '28	Mar. 14, '28	Aug. 16, '28	Aug. 31, '28	Sept. 1, '28	18 cwt.
Mill Dam Close ...	Lucerne ...	... ...	... ...	... ...	June 10,'28 Aug. 20,'28 Nov. 22,'28	June 23, '28 Sept. 5, '28 (used green)	June 23, '28 Sept. 5, '28	34 cwt. hay (1st cutting only)
Road Piece Field ...	Barley ...	Chevalier Type ...	Mar. 18, '28	Mar. 18, '28	Aug. 11, '28	Aug. 29, '28	Aug. 30, '28	15 cwt.
	Seeds ...	... ...	May 31, '27	May 31, '27	June 25,'28 Sept. 5,'28	July 2, '28	July 2, '28	25 cwt. hay
	Spring Oats ...	Swedish Victory ...	Mar. 1, '28	Mar. 2, '28	Aug. 3, '28	Aug. 20, '28	Aug. 21, '28	5–6 qrs.
Great Hill	Spring Oats ...	Swedish Victory ...	Feb. 24, '28	Feb. 25, '28	Aug. 8, '28	Aug. 22, '28	Aug. 25, '28	5–6 qrs.
Warren Field ...	Mangolds ...	Yellow Globe ...	May 30, '28	May 31, '28	Oct. 29, '28	Nov. 19, '28	Nov. 27, '28	25 tons
	Fallow ...	... ...	... ...	... ...	... ...	... ...	... ...	...

YIELDS OF

EXPERIMENTAL PLOTS

1927, 1928

https://doi.org/10.23637/ERADOC-1-85

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 it 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 (HARVEST 1927).

Field.	Crop.	Variety.	Sowing began.	Sowing finished.	Cutting began.	Carting began.*	Carting finished.*	Yield † per acre.
Gt. Knott, East ...	Wheat ...	Bountiful / Cambridge Browick	Oct. 12, '26	Oct. 14, '26	Aug. 17, '27	Aug. 29, '27	Aug. 30, '27	22 cwt.
Gt. Knott, West	Wheat ...	Million III	Oct. 7, '26	Oct. 7, '26	Aug. 23, '27	Sept. 5, '27	Sept. 5, '27	25 cwt.
Little Knott ...	Fallow ... / Grass ...	—	—	—	July 21, '27	July 26, '27	July 29, '27	—
Fosters, East ...	Winter Oats	Grey, Black	Oct. 11, '26	Oct. 12, '26	Aug. 4, '27	Aug. 24, '27	Aug. 27, '27	20 cwt.
	Spring Oats	Swedish King	Feb. 18, '27	Feb. 18, '27	Sept. 1, '27	Sept. 7, '27	Sept. 7, '27	22 cwt.
Fosters, West ...	Lucerne ...	Provence	Apr. 10, '26	Apr. 10, '26	July 19, '27	—	—	—
West Barnfield ...	Clover ...	Late Flowering Red ...	Mar. 30, '26	Mar. 30, '26	June 14, '27	June 27, '27	June 28, '27	—
Long Hoos, East...	Potatoes ...	Arran Comrade ...	May 24, '27	May 25, '27	—	Oct. 7, '27	Nov. 1, '27	7 tons
	Swedes ...	Dreadnought	June 14, '27	July 4, '27	—	Oct. 27, '27	Jan. 19, '28	19 tons
Long Hoos, West ...	Sugar Beet	Dutch Seed	June 11, '27	June 13, '27	—	Nov. 21, '27	Jan. 18, '28	3½ tons
New Zealand ...	Clover ...	Late Flowering Red ...	April 1, '26	April 1, '26	June 21, '27	July 6, '27	July 11, '27	35 cwt.
Stackyard ...	Wheat ...	Little Joss	Oct. 28, '26	Nov. 1, '26	Aug. 22, '27	Aug. 31, '27	Aug. 31, '27	17 cwt.
Gt. Harpenden ...	Barley ...	Spratt Archer	April 4, '27	April 5, '27	Sept. 6, '27	Sept. 20, '27	Oct. 5, '27	9 cwt.
	Spring Wheat	Little Joss	Mar. 9, '27	Mar. 9, '27	Sept. 5, '27	Sept. 12, '27	Sept. 13, '27	16 cwt.
Sawpit	Fallow ...	—	—	—	—	—	—	—
Sawyers	Wheat ...	Million III	Oct. 6, '26	Oct. 6, '26	Aug. 15, '27	Aug. 26, '27	Aug. 29, '27	22 cwt.
	Spring Oats	Victory	Feb. 18, '27	Feb. 19, '27	Aug. 22, '27	Aug. 30, '27	Sept. 1, '27	22 cwt.
Broadbalk ...	Wheat ... / Fallow ...	Red Standard	Oct. 8, '26	Oct. 8, '26	Aug. 26, '27	Sept. 2, '27	Sept. 3, '27	See p. 129.
Little Hoos ...	Barley ...	Plumage Archer ...	April 16, '27	April 19, '27	Sept. 2, '27	Sept. 8, '27	Sept. 13, '27	15 cwt.
Hoos	Barley ...	Spratt Archer	Mar. 25, '27	Mar. 25, '27	Sept. 1, '27	Sept. 8, '27	Sept. 21, '27	See p. 130.
Barnfield	Swedes ...	Purple Top	June 22, '27	June 22, '27	—	Nov. 4, '27	Nov. 19, '27	See p. 125.
Agdell	Wheat ...	Red Standard	Oct. 8, '26	Oct. 8, '26	Aug. 15, '27	Aug. 26, '27	Aug. 26, '27	See p. 124.
Greatfield	Grazing ...	—	—	—	—	—	—	—
Park	Hay ...	—	—	—	July 5, '27	July 18, '27	July 19, '27	See p. 126.

* In the case of roots, the dates given are those on which lifting began and finished. † Estimated yields.

https://doi.org/10.23637/ERADOC-1-85

DATES OF SOWING AND HARVESTING (HARVEST 1928).

Field.	Crop.	Variety.	Sowing began.	Sowing finished.	Cutting began.	*Carting began.	*Carting finished.	Yield † per acre.
Gt. Knott ...	Wheat ...	Million III	Nov. 4, '27	Nov. 5, '27	Aug. 15, '28	Aug. 29, '28	Aug. 30, '28	9 cwt.
Gt. Knott ...	Spring Oats	Swedish King	Feb. 28, '28	Feb. 29, '28	Aug. 14, '28	Aug. 30, '28	Aug. 30, '28	9 cwt.
Gt. Knott ...	Rape ...	—	May 22, '28	June 18, '28	—	—	—	—
Little Knott ...	Grazing ...	—	—	—	—	—	—	—
Fosters	Wheat ...	Little Joss	Nov. 7, '27	Nov. 14, '27	Aug. 16, '28	Aug. 28, '28	Aug. 29, '28	15½ cwt.
West Barnfield ...	Wheat ...	Million III	Oct. 19, '27	Oct. 20, '27	Aug. 11, '28	Aug. 21, '28	Aug. 24, '28	16½ cwt.
Long Hoos, East... / Long Hoos, West	Barley ...	Standwell ... / Plumage Archer	Feb. 19, '28	Feb. 29, '28	Aug. 9, '28	Aug. 18, '28	Sept. 5, '28	14 cwt.
New Zealand ...	Wheat ...	Million III	Nov. 2, '27	Nov. 4, '27	Aug. 20, '28	Aug. 31, '28	Aug. 31, '28	16 cwt.
Stackyard	Winter Oats	Grey	Oct. 7, '27	Oct. 8, '27	July 28, '28	Aug. 9, '28	Aug. 9, '28	22 cwt.
Gt. Harpenden ...	Sugar Beet	Dippe	May 5, '28	May 5, '28	—	Oct. 26, '28	Nov. 3, '28	9 tons
Gt. Harpenden ...	Potatoes ...	Eclipse, Ally and Majestic	April 17, '28	April 20, '28	—	Oct. 10, '28	Oct. 16, '28	Ec. 6 tons / Al. 8½ tons / Ma .8 tons
Gt. Harpenden ...	Swedes ...	Buffalo, and Picton ...	May 9, '28	May 9, '28	—	Nov. 21, '28	Dec. 19, '28	Pi. 18 tons / Bu. 21 tons
Pastures	Wheat ...	Swedish Iron / Squareheads Master / Yeoman II and / Million III	Oct. 20, '27	Oct. 21, '27	Aug. 13, '28	Aug. 29, '28	Aug. 30, '28	24 cwt. See p. 136.
Sawyers	Barley ...	Standwell and / Plumage Archer	April 10, '28	April 10, '28	Aug. 21, '28	Sept. 3, '28	Sept. 5, '28	14 cwt.
Broadbalk ...	Wheat ...	Red Standard	Oct. 18, '27	Oct. 18, '27	Aug. 6, '28	Aug. 16, '28	Aug. 16, '28	See p. 129.
Broadbalk ...	Fallow ...	—	—	—	—	—	—	—
Little Hoos ...	Clover ...	Broad Red Hay ...	April 19, '27	April 19, '27	June 22, '28	June 28, '28	June 29, '28	28 cwt.
		Broad Red Seed ...	April 19, '27	April 19, '27	Sept. 19, '28	Oct. 2, '28	Oct. 3, '28	3¼ cwt.
Hoos	Barley ...	Plumage Archer ...	April 27, '28	April 27, '28	Oct. 1, '28	Oct. 22, '28	Oct. 22, '28	See p. 130.
Barnfield	Mangolds ...	Prize-winner	May 2, '28	May 2, '28	—	Nov. 5, '28	Nov. 14, '28	See p. 125.
Agdell	Swedes ...	Dreadnought	May 25, '28	May 25, '28	—	Nov. 14, '28	Nov. 20, '28	See p. 124.
Greatfield	Grazing ...	—	—	—	—	—	—	—
Park	Hay ...	—	—	—	June 25, '28	July 2, '28	July 2, '28	See p. 126.

* In the case of roots, the dates given are those on which lifting began and finished. † Estimated yields.

https://doi.org/10.23637/ERADOC-1-85

CROP YIELDS ON THE EXPERIMENTAL PLOTS.

NOTES.—In each case the year refers to the harvest, *e.g.*, Wheat 1928 means wheat harvested in 1928. In the tables, total straw includes straw, cavings and chaff. These were weighed separately prior to 1928. In 1928 the figure given as total straw was 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 lbs.	
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 metric Quintals per Hectare	117.4 Rotls per Feddan
1 ton per acre ... =	25.12 metric Quintals per Hectare (dz/ha).	

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

CONVERSION TABLE.—CWTS. TO BUSHELS.

CROP.	Cwts. 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. Cwts.	Country.	Mean yield per acre, 1919-27. Cwts.
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, 1927 and 1928.

	Rain.		Drainage through soil.				Temperature (Mean).				
	Total Fall $\frac{1}{1000}$th Acre Gauge.	No. of Rainy Days. (0.01 inch or more) $\frac{1}{1000}$th Acre Gauge.	20 ins. deep.	40 ins. deep.	60 ins. deep.	Bright Sun-shine.	Max.	Min.	1 ft. in ground.	Solar Max.	Grass Min.
1927.	Inches.	No.	Inches.	Inches.	Inches.	Hours.	°F.	°F.	°F.	°F.	°F.
Jan. ...	2.408	18	1.865	1.995	1.842	62.9	43.9	33.5	38.3	72.3	29.4
Feb. ...	3.982	15	3.435	3.630	3.496	46.0	43.1	33.1	37.8	73.9	29.8
Mar. ...	2.384	18	0.960	1.113	1.038	124.9	50.5	38.8	42.6	101.4	33.2
April ...	1.855	12	1.205	1.588	1.484	165.6	53.0	38.6	46.0	114.9	33.3
May ...	1.187	11	0.000	0.019	0.019	226.4	61.6	42.9	52.7	121.5	37.6
June ...	3.564	19	0.745	0.739	0.723	183.7	62.5	46.8	56.3	127.8	42.1
July ...	3.112	20	1.651	2.073	1.889	130.4	65.4	53.6	59.4	121.8	49.5
Aug. ...	4.348	19	1.852	2.100	1.967	178.4	66.8	53.2	60.4	129.6	48.2
Sept. ...	5.451	17	3.704	3.899	3.823	111.3	59.7	48.1	56.2	111.5	43.8
Oct. ...	2.197	17	1.268	1.413	1.342	97.5	56.4	44.0	50.6	97.4	38.7
Nov. ...	3.008	18	2.338	2.682	2.366	54.6	46.4	36.5	44.7	72.1	33.2
Dec. ...	3.013	12	2.464	2.853	2.761	31.5	37.0	30.5	38.5	51.2	28.8
Total or Mean ...	36.509	196	21.487	24.104	22.750	1413.2	53.9	41.6	48.6	99.6	37.3
1928.											
Jan. ...	4.109	21	4.413	5.662	4.571	64.9	45.9	33.3	37.6	73.1	29.2
Feb. ...	2.075	10	1.447	1.832	1.710	100.2	48.0	35.0	39.5	88.2	29.7
Mar. ...	2.404	17	1.093	1.318	1.283	92.8	48.1	36.1	41.3	94.0	31.7
April ...	0.905	13	0.351	0.646	0.589	127.3	52.9	38.1	45.1	103.3*	32.7†
May ...	1.448	12	0.066	0.170	0.136	169.8	59.2	42.2	50.9	112.8	37.3
June ...	2.204	14	0.160	0.279	0.246	230.0	63.5	47.3	56.8	124.0	42.6
July ...	2.511	6	0.457	0.439	0.434	276.3	71.9	52.9	62.9	129.8	47.3
Aug. ...	2.216	12	0.496	0.734	0.672	193.0	66.5	52.1	60.3	121.9	47.7
Sept. ...	0.785	4	0.000	0.039	0.017	212.0	63.7	46.3	56.2	116.1	38.8
Oct. ...	3.867	19	2.287	2.458	2.284	126.5	56.4	43.1	49.8	98.2	38.0
Nov. ...	3.161	16	2.217	2.647	2.447	72.1	50.4	39.7	45.2	80.4	36.3
Dec. ...	2.773	17	2.045	2.485	2.341	48.9	41.7	32.1	38.5	61.7	28.4
Total or Mean	28.458	161	15.032	18.709	16.730	1713.8	55.7	41.5	48.7	100.3	36.6

* Mean of 21 observations only.
† Mean of 29 observations only.

RAIN AND DRAINAGE.
MONTHLY MEAN FOR 58 HARVEST YEARS, 1870-1—1927-8.

	Rainfall.	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.
September	2.426	0.832	0.805	0.742	34.3	33.2	30.6	1.594	1.621	1.684
October ...	3.135	1.808	1.772	1.647	57.7	56.5	52.5	1.327	1.363	1.488
November	2.774	2.102	2.149	2.024	75.8	77.5	73.0	0.672	0.625	0.750
December	2.819	2.403	2.496	2.383	85.2	88.5	84.5	0.416	0.323	0.436
January	2.419	1.984	2.182	2.083	82.0	90.2	86.1	0.435	0.237	0.336
February	2.073	1.547	1.656	1.581	74.6	79.9	76.3	0.526	0.417	0.492
March ...	2.040	1.088	1.221	1.154	53.3	59.9	56.6	0.952	0.819	0.886
April ...	2.030	0.664	0.743	0.708	32.7	36.6	34.9	1.366	1.287	1.322
May ...	2.029	0.469	0.534	0.501	23.1	26.3	24.7	1.560	1.495	1.528
June ...	2.267	0.557	0.586	0.564	24.6	25.8	24.9	1.710	1.681	1.703
July ...	2.748	0.737	0.766	0.712	26.8	27.9	25.9	2.011	1.982	2.036
August ...	2.683	0.715	0.728	0.683	26.6	27.1	25.5	1.968	1.955	2.000
Year ...	29.443	14.906	15.638	14.782	50.6	53.1	50.2	14.557	13.805	14.661

Area of each gauge $\frac{1}{1000}$th acre.

CHEMICAL ANALYSES OF FERTILISERS USED IN REPLICATED EXPERIMENTS, 1927-8.

Fertiliser.	% N	% water-sol. P_2O_5	% K_2O
Sulphate of Ammonia ...	20.67-21.20	—	—
Muriate of Ammonia ...	25.54-26.08	—	—
Nitrate of Soda	15.37	—	—
Urea	46.48	—	—
Cyanamide	19.39–19.75	—	—
Nitrochalk	10.00	—	—
Ammonium Phosphate ...	12.15	61.6	—
Superphosphate	—	16.79-16.94	—
Potassium Phosphate (K_2HPO_4)	—	40.80	54.03
Sulphate of Potash ...	—	—	49.48-49.58
Muriate of Potash	—	—	51.00-51.83
Potash Manure Salts (30%)	—	—	32.60
Nitrophoska	10.3 as NH_4 : 5.3 as NO_3	12.86	25.9
Compound Fertiliser " B "...	10.09	9.90	18.25

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 & 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
	Twentieth Course, 1924-27.							
1924	Roots (Turnips)	cwt.	2.9	0.7	42.8	31.5	127.4	104.7
1925	Barley—							
	Dressed Grain	bush.	10.86	7.35	10.09	16.70	10.35	8.60
	Offal Grain	lb.	42.0	49.0	94.0	38.0	53.0	59.0
	Straw	lb.	633.0	678.0	602.0	866.0	626.0	541.0
	Total Straw†	cwt.	7.2	7.5	7.4	9.3	7.0	6.5
	Wt. of Dressed Grain per bushel	lb.	52.7	51.6	52.5	53.6	53.3	54.3
	Proportion of Total Grain to 100 of Total Straw		76.3	50.7	75.5	89.2	77.0	72.4
1926	Clover Hay	cwt.	—	14.2	—	32.2	—	26.3
1927	Wheat—							
	Dressed Grain	bush.	20.15	12.86	19.07	19.01	16.28	15.77
	Offal Grain	lb.	57.0	66.0	73.0	72.0	47.0	53.0
	Straw	lb.	1859.0	1846.0	2111.0	1932.0	1878.0	1693.0
	Total Straw†	cwt.	18.6	19.6	21.8	20.5	19.1	17.4
	Wt. of Dressed Grain per bush.	lb.	60.1	61.2	59.6	60.6	59.5	59.8
	Proportion of Total Grain to 100 of Total Straw		60.9	38.9	49.6	53.3	47.5	51.2
	Present Course (21st), 1928.							
1928	Roots (Swedes)	cwt.	19.7	11.7	143.8	163.6	293.2	223.2

* Plots 1, 3 and 5 based upon 18 years. Plots 2, 4 and 6 based upon 17 years.
† Includes straw, cavings and chaff.
Manures applied once every four years, prior to sowing of swedes.
‡ 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 cake per acre.

MANGOLDS—BARNFIELD, 1927 and 1928.

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

PRODUCE PER ACRE.

	Strip.	Strip Manures. (Amounts stated as per acre).	1927.†					1928.					50-year Average 1876–1928.††				
				Cross Dressings.					Cross Dressings.					Cross Dressings.			
			O	N	A	AC	C	O	N	A	AC	C	O	N	A	AC	C
			None.	Nitrate of Soda (550 lbs.)	Sulphate of Amm'nia (412 lbs.)	Sulphate of Amm'nia (412 lbs.) & Rape Cake	Rape Cake (2,000 lbs.)	None.	Nitrate of Soda (550 lbs.)	Sulphate of Amm'nia (412 lbs.)	Sulphate of Amm'nia (412 lbs.) & Rape Cake	Rape Cake (2,000 lbs.)	None.	Nitrate of Soda (550 lbs.)	Sulphate of Amm'nia (412 lbs.)	Sulphate of Amm'nia (412 lbs.) & Rape Cake	Rape Cake (2,000 lbs.)
ROOTS.	1	Dung only (14 tons)	Tons 12.22	Tons 15.02	Tons 15.66	Tons 16.92	Tons 14.39	Tons 12.11	Tons 27.07	Tons 20.33	Tons 18.30	Tons 16.21	Tons 17.47	Tons 26.16	Tons 21.70	Tons 23.58	Tons 23.53
	2	Dung, Superphosphate (3½ cwts.), Sulphate of Potash (500 lbs.) ...	10.01	14.77	15.41	17.34	15.37	16.53	29.25	26.98	29.15	24.68	18.94	26.68	24.71	27.57	26.50
	4	Complete Minerals: Super and Potash as 2, Salt (200 lb.) Sulphate of Magnesia (200 lb.)	1.07	(a) 7.90* (b) 6.69	6.59	13.42	9.50	4.25	(a) 23.30* (b) 21.84	19.80	29.22	23.67	4.60	(a) 18.11** (b) 17.81	14.37	26.06	20.96
	5	Superphosphate only (3½ cwt.) ...	1.77	6.90	8.08	12.79	10.89	3.47	18.44	9.39	9.55	10.68	4.47	14.63	6.70	9.49	10.16
	6	Super (3½ cwt.) Sulphate of Potash (500 lbs.)	0.98	4.04	4.39	10.96	7.51	4.03	19.15	18.26	24.73	19.76	4.03	15.12	13.50	22.55	18.14
	7	Super (3½ cwt.) Sulphate of Magnesia (200 lbs.) and Sodium Chloride (200 lbs.)	1.20	5.37	4.97	12.20	8.65	4.17	20.12	18.93	24.62	21.40	4.86	16.04	14.70	22.31	19.10
	8	No Minerals	1.17	3.36	4.35	10.54	9.07	2.85	11.65	6.05	8.89	9.24	3.34	9.61	5.32	8.52	8.89
	9	Sodium Chloride (200 lbs.), Nit. Soda (550 lb.), Sulph. Potash (500 lbs.) and Sulph. Mag. (200 lbs.)	6.05	—	—	—	—	21.27	—	—	—	—	—	—	—	—	—
LEAVES.	1	Dung only (14 tons)	3.14	3.17	3.63	4.51	4.01	2.97	4.47	3.79	3.22	2.60	3.04	4.65	4.93	5.25	4.54
	2	Dung, Superphosphate (3½ cwts.), Sulphate of Potash (500 lbs.) ...	2.35	3.43	3.73	4.79	4.08	2.82	4.50	4.52	6.07	4.66	3.16	5.15	5.49	6.29	4.80
	4	Complete Minerals: Super and Potash as 2, Salt (200 lbs.), Sulphate of Magnesia (200 lbs.)	0.23	(a) 1.50* (b) 1.37	1.60	3.89	2.35	0.85	(a) 3.47* (b) 3.73	2.41	5.01	3.40	1.04	(a) 4.05** (b) 4.09	2.88	5.33	3.37
	5	Superphosphate only (3½ cwts.) ...	0.41	1.17	1.70	3.59	2.67	0.99	2.60	2.58	2.83	2.75	1.05	3.19	2.61	3.29	2.84
	6	Super (3½ cwts.), Sulphate of Potash (500 lbs.)	0.25	0.66	0.72	2.44	1.31	0.87	2.05	2.31	4.60	2.61	0.93	3.04	2.81	5.20	2.87
	7	Super (3½ cwts.), Sulphate of Magnesia (200 lbs.) and Sodium Chloride (200 lbs.)	0.28	0.62	0.63	2.52	1.21	0.92	3.08	3.13	5.05	3.47	1.10	3.31	3.01	5.23	3.31
	8	No Minerals	0.30	0.54	0.92	2.90	1.92	0.86	3.76	2.75	3.27	2.99	0.98	3.19	2.52	3.30	2.84
	9	Sodium Chloride (200 lbs.), Nit. Soda (550 lbs.), Sulph. Potash (500 lbs.) and Sulph. Mag. (200 lbs.) ...	0.91	—	—	—	—	3.78	—	—	—	—	—	—	—	—	—

* From 1904 onwards plot 4 N 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 lbs.), Potassium Nitrate (570 lbs.), and Calcium Nitrate (100 lbs.). 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.

† In 1927 Mangolds failed and the whole field was re-sown with Swedes. In this year only one-third of the nitrogen was supplied, this being given at time of sowing of mangolds.

†† 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, 1927-1928.

Plot.	Manuring (amounts stated are per acre).		1927 Yield of Hay per acre. 1st Crop.	1927 Yield of Hay per acre. 2nd§ Crop.	1927 Yield of Hay per acre. Total.	1927 Dry Matter per acre. 1st Crop.	1927 Dry Matter per acre. 2nd Crop.	1927 Dry Matter per acre. Total.	1928 Yield of Hay per acre. 1st Crop.	1928 Yield of Hay per acre. 2nd§ Crop.	1928 Yield of Hay per acre. Total.	1928 Dry Matter per acre. 1st Crop.	1928 Dry Matter per acre. 2nd Crop.	1928 Dry Matter per acre. Total.	Plot.
			cwt.	cwt.	cwt.	lb.	lb.	lb.	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	5.0	11.8	16.8	427	1057	1484	8.0	3.2	11.2	652	286	938	1
		limed ...	9.8	8.1	17.9	805	729	1534	14.8	4.2	19.0	1238	380	1618	
2	Unmanured (after Dung 8 years, 1856–63)	not limed	5.3	8.6	13.9	432	769	1201	11.2	3.3	14.5	904	299	1203	2
		limed ...	4.4	6.1	10.5	336	543	879	12.0	1.7	13.7	948	152	1100	
3	Unmanured	not limed	4.5	5.5	10.0	346	492	838	9.3	2.1	11.4	742	188	930	3
		limed ...	2.8	5.6	8.4	203	499	702	7.8	1.6	9.4	634	144	778	
4-1	Superphosphate of Lime (3½ cwt.) ...	not limed	6.0	8.0	14.0	434	714	1148	16.0	3.1	19.1	1236	275	1511	4-1
		limed ...	3.1	7.4	10.5	221	659	880	8.5	2.0	10.5	649	179	828	
4-2	Superphosphate of Lime (3½ cwt.) and double dressing (412 lb.) Sulphate of Ammonia (=86 lb. N.)	not limed	4.9	12.6	17.5	368	1133	1501	11.6	2.0	13.6	1039	183	1222	4-2
		limed ...	15.6	14.8	30.4	1430	1324	2754	32.2	7.3	39.5	2931	652	3583	
5-1	(N. half) Unmanured following double dressing Amm. Salts (=86 lb. N.) 1856–97...	not limed	5.5	5.8	11.3	433	519	952	6.0	3.7	9.7	492	327	819	5-1
5-2	(S. half) Superphosphate (3½ cwt.); Sulphate of Potash (500 lb.): following double dressing Amm. Salts (=86 lb. N.) 1856–97	not limed	10.2	13.0	23.2	787	1169	1956	14.8	6.6	21.4	1267	593	1860	5-2
6	Complete Mineral Manure as Plot 7; following double dressing Amm. Salts (=86 lb. N.) 1856-68	not limed	17.7	12.1	29.8	1330	1084	2414	20.9	7.1	28.0	1796	639	2435	6
7	Complete Mineral Manure: Super. (3½ cwt.); Sulphate of Potash (500 lb.); Sulphate of Soda (100 lb.); Sulphate of Magnesia (100 lb.).	not limed	19.9	13.5	33.4	1320	1208	2528	21.7	13.1	34.8	1837	1177	3014	7
		limed ...	14.8	12.8	27.6	1142	1149	2291	36.2	15.1	51.3	3117	1351	4468	
8	Mineral Manure without Potash ...	not limed	10.8	11.3	22.1	633	1016	1649	14.4	7.4	21.8	1149	658	1807	8
		limed ...	7.2	7.9	15.1	488	704	1192	12.2	3.7	15.9	1096	328	1424	
9	Complete Mineral Manure and double dressing (412 lb.) Sulphate of Ammonia (=86 lb. N.)	not limed	30.8	20.4	51.2	2203	1826	4029	31.0	7.2	38.2	2646	645	3291	9
		limed ...	42.6	21.0	63.6	3138	1881	5019	50.6	8.1	58.7	4628	723	5351	
10	Mineral Manure (without Potash) and double dressing Amm. Salts (=86 lb. N.)	not limed	10.5	14.5	25.0	759	1301	2060	22.3	5.0	27.3	1933	451	2384	10
		limed ...	27.9	19.7	47.6	2276	1762	4038	39.0	10.9	49.9	3531	974	4505	

11-1	Complete Mineral Manure and treble dressing (618 lb.) Sulphate Ammonia (129 lb. N.)	not limed	41.4	28.6	70.0	2849	2565	5414	52.9	13.7	66.6	3985	1223	5208	11-1
		limed ...	32.9	23.8	56.7	2501	2132	4633	63.1	10.1	73.2	5574	906	6480	
11-2	As Plot 11-1 and Silicate of Soda ...	not limed	50.4	15.1	65.5	3257	1351	4608	61.9	14.5	76.4	4741	1302	6043	11-2
		limed ...	43.1	16.3	59.4	3110	1458	4568	59.7	16.2	75.9	5252	1449	6701	
12	Unmanured	not limed	7.4	8.3	15.7	591	739	1330	10.9	6.9	17.8	812	621	1433	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	39.4	14.8	54.2	2689	1326	4015	46.6	11.8	58.4	3615	1056	4671	13
		limed ...	35.5	14.8	50.3	2748	1329	4077	38.8	9.5	48.3	3178	855	4033	
14	Complete Mineral Manure and double dressing (550 lb.) Nitrate of Soda (=86 lb. N.)	not limed	48.1	16.7	64.8	3273	1492	4765	50.3	12.8	63.1	4534	1149	5683	14
		limed(sun)	37.1	11.1	48.2	2709	997	3706	50.6	7.1	57.7	4304	632	4936	
		lmd.(shade)	40.2	15.4	55.6	2590	1379	3969	39.2	7.7	46.9	3260	691	3951	
15	Complete Mineral Manure as Plot 7; following double dressing Nitrate of Soda (=86 lb. N., 1858-1875) ...	not limed	19.9	11.9	31.8	1554	1062	2616	25.7	7.9	33.6	2233	711	2944	15
		limed ...	12.4	9.0	21.4	1028	808	1836	27.0	3.5	30.5	2332	314	2646	
16	Complete Mineral Manure and single dressing (275 lb.) Nitrate of Soda (=43 lb. N.)	not limed	32.9	11.9	44.8	2458	1062	3520	38.0	10.0	48.0	3270	893	4163	16
		limed ...	26.6	9.9	36.5	1947	884	2831	35.6	6.2	41.8	3074	555	3629	
17	Single dressing (275 lb.) Nitrate of Soda (=43 lb. N.)	not limed	15.8	8.5	24.3	1031	765	1796	21.8	7.3	29.1	1690	652	2342	17
		limed ...	12.7	9.6	22.3	1105	857	1962	24.7	4.1	28.8	2043	365	2408	
18	Mineral Manure (without Super.), and double dressing Sulphate of Amm. (=86 lb. N.), 1905 and since; following Minerals and Amm. Salts supplying the constituents of 1 ton of Hay, 1865-1904	not limed	14.3	23.5	37.8	987	2106	3093	13.9	8.8	22.7	1293	787	2080	18
		limed 6788 lb.	44.4	26.3	70.7	3222	2360	5582	48.2	11.2	59.4	4186	1002	5188	
		limed (3951 lb.)	36.2	22.0	58.2	2370	1975	4345	31.5	6.9	38.4	2817	617	3434	
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	19.9	13.3	33.2	1545	1193	2738	22.3	11.4	33.7	2034	1021	3055	19
		limed 3150 lb.)	12.6	9.0	21.6	920	802	1722	18.4	6.6	25.0	1642	592	2234	
		limed (570 lb.)	19.1	10.1	29.2	1450	904	2354	24.4	6.5	30.9	2165	584	2749	
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	28.3	19.4	47.7	2217	1737	3954	37.3	10.3	47.6	3508	924	4432	20
		limed (2772 lb.)	20.4	12.8	33.2	1647	1142	2789	34.7	6.2	40.9	3120	557	3677	
		limed (570 lb.)	25.5	12.2	37.7	1924	1093	3017	37.5	6.7	44.2	3337	600	3937	

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, 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.

The Park Grass Plots.

BOTANICAL COMPOSITION, PER CENT., 1925, 1st CROP.

Plot.	Manuring.	Liming.	Gramineæ.	Leguminosæ.	Other Orders	"Other Orders" consist largely of	Plot.
3	Unmanured	Limed ...	73.4	5.4	21.2	Plantago lanceolata; Centaurea nigra	3
		Unlimed ...	61.1	5.1	33.8	Plantago lanceolata	
7	Complete Mineral Manure ...	Limed ...	75.2	1.2	23.6	Heracleum sphondylium; Rumex acetosa	7
		Unlimed ...	72.7	6.4	20.9	Heracleum sphondylium; Rumex acetosa	
9	Complete Mineral Manure and double Amm. Salts	Limed ...	99.5	0.0	0.5	——	9
		Unlimed ...	96.7	0.0	3.3	Heracleum sphondylium; Rumex acetosa	
14	Complete Mineral Manure and double Nitrate of Soda ...	Limed (sun)	83.6	0.0	16.4	Anthriscus sylvestris; Taraxacum vulgare	14
		,, (shade)	90.6	5.7	3.7	Anthriscus sylvestris	
		Unlimed ...	86.3	0.2	13.5	Anthriscus sylvestris; Taraxacum vulgare; Rumex acetosa	
15	As plot 7 following double Nitrate of Soda, 1858–75	Limed ...	66.1	14.8	19.1	Plantago lanceolata; Ranunculus spp.	15
		Unlimed ...	62.1	4.7	33.2	Plantago lanceolata; Achillea millefolium	
17	Single Nitrate of Soda	Limed ...	78.1	0.5	21.4	Plantago lanceolata; Centaurea nigra	17
		Unlimed ...	74.7	0.1	25.2	Plantago lanceolata	
18	Mineral Manure (without Super.) and double Sulphate Amm. 1905 and since	L. 6,788 lb.	92.0	0.2	7.8	Rumex acetosa; Centaurea nigra	18
		L. 3,951 lb.	88.5	0.0	11.5	Rumex acetosa	
		Unlimed ...	87.0	0.0	13.0	Rumex acetosa; Centaurea nigra	
19	Farmyard Dung in 1905 and every 4th year since (omitted 1917) ...	L. 3,150 lb.	84.8	1.5	13.7	Ranunculus spp.; Anthriscus sylvestris	19
		L. 570 lb....	75.7	3.2	21.1	Ranunculus spp.; Rumex acetosa...	
		Unlimed ...	82.6	3.9	13.5	Ranunculus spp.; Rumex acetosa...	
20	Farmyard Dung in 1905 and every 4th year since (omitted in 1917), each intervening year Sulphate of Potash, Super., and Nitrate of Soda	L. 2,772 lb.	63.3	4.3	32.4	Ranunculus spp.; Anthriscus sylvestris; Taraxacum vulgare	20
		L. 570 lb....	76.9	2.5	20.6	Anthriscus sylvestris; Rumex acetosa	
		Unlimed ...	68.8	10.4	20.8	Centaurea nigra; Anthriscus sylvestris; Ranunculus spp.	

WHEAT—BROADBALK FIELD.

Plot.	Manurial Treatment (amounts stated are per acre).	1927 (lower part) 84th successive crop. Dressed Grain. Yield per acre.	Weight per bushel.	Yield per acre.	Offal Grain per acre.	Straw per acre.	Total† Straw per acre.	Proportion of Total Grain to 100 of Total Straw.	1928 (upper part): after 2 years fallow. Dressed Grain. Yield per acre.	Weight per bushel.	Yield per acre.	Offal Grain per acre.	Straw per acre.	Total† Straw per acre.	Proportion of Total Grain to 100 of Total Straw.	77-year Average 1852–1928 Dressed Grain per acre.	Total Straw per acre.
		bush.	lb.	cwt.	lb.	lb.	cwt.		bush.	lb.	cwt.	lb.	lb.	cwt.		bush.	cwt.
2A	Farmyard Manure (14 tons)	19.5	58.1	10.1	132	2108	24.0	47.3	41.1	64.9	23.8	75	5225	51.3	47.5	26.3**	32.3**
2B	Farmyard Manure (14 tons)	24.2	57.9	12.5	156	2667	30.7	45.7	48.4	65.4	28.3	89	6283	61.4	47.6	33.2	34.5
3	Unmanured since 1839	6.9	59.2	3.7	39	593	6.9	58.4	27.9	63.9	15.9	56	2730	27.8	59.4	11.8	9.9
5	Complete Mineral Manure§§	6.5	59.2	3.4	28	590	6.7	55.6	35.2	64.5	20.3	63	3505	34.8	60.4	13.6	11.6
6	As 5, and 206 lb. Sulphate of Ammonia	12.5	58.6	6.5	53	1255	13.9	50.5	47.3	64.7	27.3	77	4970	48.7	58.0	21.7	20.5
7	As 5, and 412 lb. Sulphate of Ammonia ...	21.5	56.8	10.9	174	2730	30.3	41.4	67.4*	60.6*	36.5*	31*	6165*	57.8*	63.6*	30.5	32.2
8	As 5, and 618 lb. Sulphate of Ammonia ...	25.9	54.6	12.6	193	3105	35.3	40.7	57.2	65.6	33.4	116	6105	62.0	55.6	34.3	40.0
9	As 5, and 275 lb. Nitrate of Soda	16.6	57.6	8.6	122	1838	20.7	46.7	56.1	61.2	30.6	40	5298	50.3	61.5	23.8††	24.9††
10	412 lb. Sulphate of Ammonia	12.0	56.9	6.1	145	1358	16.5	44.8	47.0	61.6	25.8	44	4375	42.8	61.4	18.8	18.1
11	As 10, and Super-phosphate (3½ cwt.)	8.9	52.4	4.2	160	1565	18.8	29.9	56.9	61.9	31.4	62	5838	57.7	56.5	21.4	21.8
12	As 10, and Super. (3½ cwt.) and Sulph. Soda (366 lb.)	13.5	55.0	6.6	184	1895	22.5	36.7	57.3	64.5	33.0	95	5585	55.5	61.3	27.0	27.1
13	As 10, and Super. (3½ cwt.) and Sulph. Potash (200 lb.)	17.4	56.5	8.8	158	2223	25.2	40.4	55.2	65.0	32.0	98	5755	56.2	58.6	29.2	30.8
14	As 10, and Super. (3½ cwt.) and Sulph. Magnesia (280 lb.)	16.3	56.1	8.1	125	2043	22.8	40.9	58.6	63.0	33.0	67	5658	54.7	61.6	26.7	27.0
15	As 5, and 412 lb. Sulphate of Ammonia, all applied in autumn	11.1	57.0	5.6	90	1208	14.2	45.8	52.3	64.3	30.0	62	5813	56.6	54.2	27.6	28.2
16	As 5, and 550 lb. Nitrate of Soda	18.1	55.5	8.9	170	2330	26.2	39.7	56.1	64.6	32.4	92	5615	55.8	59.8	29.7††	35.3††
17	Minerals alone as 5 or 412 lb. Sulphate of Ammonia alone in alternate years	M6.5	58.2	3.4	65	840	9.3	42.3	A51.8	64.3	31.4	88	5580	54.9	58.7	A27.9	28.3
18		A15.3	59.2	8.1	189	2280	26.0	38.3	M38.8	64.6	22.4	70	3908	38.7	59.6	M14.1	12.6
19	Rape Cake (1889 lb.)	10.1	58.3	5.2	184	2268	26.3	26.2	52.7	64.5	30.4	94	5385	53.3	58.7	20.9‡	22.9‡
20	As 7, without Super.	—	—	—	—	—	—	—	39.3	64.3	22.5	76	4332	44.2	52.5	17.7§	20.0§

† Includes Straw, cavings and chaff. 1927, top portion fallowed; 1928, bottom portion fallowed. * Estimated from half plot.
** 29 years only, 1900–1928. †† 44 years only, 1885–1928. ‡ 36 years only, 1893–1928. § 19 years only, 1906–1928 (no crop in 1912, 1914, 1926 and 1927).

In 1926 and 1927 the crop was confined to the lower part of the field, the upper part being completely fallowed for 2 years. This was the first complete fallow since the experiment began in 1843. In October, 1927, the upper part was sown with wheat, and the yields for 1928 are given above.

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.

§§ Complete Mineral Manure: 3½ cwt. Super, 200 lb. Sulph. Potash, 100lb. Sulph. Soda, 100 lb. Sulph. Magnesia.

J

PERMANENT BARLEY PLOTS, Hoos Field, 1927 and 1928.

PRODUCE PER ACRE.

Plot.	Manuring (amounts stated are per acre)	1927. Dressed Grain. Yield per acre.	1927. Dressed Grain. Weight per bush.	1927. Dressed Grain. Yield per acre.	1927. Offal Grain per acre.	1927. Straw per acre.	1927. Total†† Straw per acre.	1927. Proportion of Total Grain to 100 of Total Straw.	1928. Dressed Grain. Yield per acre.	1928. Dressed Grain. Weight per bush.	1928. Dressed Grain. Yield per acre.	1928. Offal Grain per acre.	1928. Straw per acre.	1928. Total†† Straw per acre.	1928. Proportion of Total Grain to 100 of Total Straw.	76 years' Average Yield 1852–1928.† Dressed Grain per acre.	76 years' Average Yield 1852–1928.† Total†† Straw per acre.
		bush.	lb.	cwt.	lb.	lb.	cwt.		bush.	lb.	cwt.	lb.	lb.	cwt.		bush.	cwt.
1O	Unmanured	9.1	52.1	4.2	16	338	4.6	94.8	5.0	44.0	2.0	18	363	4.1	51.3	13.4	7.8
2O	Superphosphate only (3½ cwt.)	11.9	49.9	5.3	27	506	7.2	76.5	11.9	46.0	4.9	31	701	8.1	63.9	19.0	9.8
3O	Alkali Salts only (200 lb. Sulphate of Potash; 100 lb. Sulphate of Soda; 100 lb. Sulphate of Magnesia)	4.9	50.5	2.2	53	707	11.6	22.9	6.5	43.1	2.5	21	743	8.4	32.0	14.3	8.7
4O	Complete Minerals; as 3O with Superphosphate (3½ cwt.)	5.3	50.8	2.4	139*a*	1507	22.5	16.2	10.6	45.5	4.3	37	1133	13.1	35.2	19.0	11.2
5O	Potash (200 lb.) and Superphosphate (3½ cwt.)	7.7	49.8	3.4	18	374	6.1	58.7	5.4	42.0	2.0	28	737	8.1	28.2	15.5	9.4
1A	Ammonium Salts only (206 lb. Sulphate of Ammonia)	23.2	50.8	10.5	29	902	11.1	97.3	7.4	42.8	2.8	25	520	6.3	47.8	23.7	13.7
2A	Superphosphate and Amm. Salts	16.2	49.8	7.2	40	723	9.6	78.9	11.8	44.3	4.7	28	781	9.3	52.8	35.8	20.4
3A	Alkali Salts and Amm. Salts	17.0	47.8	7.2	40	1059	14.7	51.6	11.2	43.8	4.4	39	1015	12.2	38.5	25.8	16.0
4A	Complete Minerals and Amm. Salts	21.7	50.9	9.8	42	1304	18.0	56.9	11.4	45.8	4.7	23	1275	14.7	33.1	39.3	23.6
5A	Potash, Super. and Amm. Salts	21.4	49.0	9.4	38	1249	17.0	57.2	3.0	42.0	1.1	8	891	9.9	12.2	33.8	21.7
1AA	Nitrate of Soda only (275 lb.)	29.6	51.5	13.6	44	1403	16.9	82.6	8.8	42.0	3.3	41	924	10.8	34.1	24.3*	15.4*
2AA	Superphosphate and Nitrate of Soda ...	33.6	50.0	15.0	44	1337	16.0	96.1	13.8	44.8	5.5	28	1243	14.7	39.0	38.8*	23.1*
3AA	Alkali Salts and Nitrate of Soda	19.2	51.3	8.8	43	1507	22.0	41.6	9.1	41.5	3.4	39	1337	14.7	25.4	24.5*	16.6*
4AA	Complete Minerals and Nitrate of Soda ...	30.7	51.0	14.0	44	1540	20.2	71.1	11.1	44.5	4.4	23	1414	17.8	25.8	37.7*	23.6*
1AAS	As Plot 1AA and Silicate of Soda (400 lb.) ...	31.9	51.4	14.6	44	864	12.0	125.1	11.0	43.5	4.3	34	1007	11.4	40.3	30.2*	18.2*
2AAS	As Plot 2AA and Silicate of Soda (400 lb.) ...	33.8	50.4	15.2	49	1474	18.1	86.5	11.0	46.0	4.5	19	1018	12.6	37.2	39.7*	23.9*
3AAS	As Plot 3AA and Silicate of Soda (400 lb.) ...	24.1	50.6	10.9	29	1067	14.2	78.9	8.4	46.0	3.4	32	946	12.1	30.8	31.2*	19.9*
4AAS	As Plot 4AA and Silicate of Soda (400 lb.) ...	29.8	51.3	13.6	45	1557	20.4	68.7	9.7	46.0	4.0	20	1243	16.4	25.5	39.9*	25.4*
1C	Rape Cake only (1000 lb.)	30.4	52.3	14.2	29	1485	17.9	80.4	10.1	42.8	3.8	23	1141	13.6	29.8	35.5	20.6
2C	Superphosphate and Rape Cake	40.9	50.5	18.4	37	1672	20.6	91.2	12.9	44.7	5.2	20	1287	15.5	34.3	38.1	22.0
3C	Alkali Salts and Rape Cake	21.1	48.5	9.2	65	982	13.6	71.8	7.0	43.5	2.7	20	908	11.3	25.7	33.7	20.4
4C	Complete Minerals and Rape Cake	30.9	50.6	14.0	39	1526	19.2	74.5	9.9	44.0	3.9	20	1419	16.3	24.9	37.5	22.6
7-1	Unmanured (after dung (14 tons) for 20 years 1852-71)	12.9	50.4	5.8	31	636	9.2	66.1	7.6	41.5	3.7	34	913	11.1	27.9	22.5‡	13.5‡
7-2	Farmyard Manure (14 tons)	40.4	50.5	18.2	63	2004	28.3	66.5	8.6	42.0	5.1	37	1166	13.2	26.8	44.6	28.1
6-1	Unmanured since 1852	5.2	50.5	2.4	20	266	4.3	58.7	7.4	43.0	2.8	25	515	6.2	49.3	14.7	8.6
6-2	Ashes from Laboratory furnace	8.4	48.8	3.7	27	420	6.8	57.4	12.0	44.5	4.8	33	704	8.6	59.0	15.7	9.3
1N	Nitrate of Soda only (275 lb.)	25.3	49.4	11.2	43	1232	15.5	74.4	9.4	44.3	2.8	18	924	10.6	36.8	28.7§	17.8§
2N	Nitrate of Soda only (275 lb.)	26.7	48.8	11.7	34	1205	16.1	74.2	12.7	44.8	3.2	28	2593	29.0	18.4	31.7§§	20.0§§

† **1912**, all plots were fallowed. * 60 years, 1868-1928. ‡ 56 years, 1872-1928. § 75 years, 1853-1928. §§ 69 years, 1859-1928.
a A large amount of black medic seed in Offal Grain. †† Includes straw, cavings and chaff.

https://doi.org/10.23637/ERADOC-1-85

Second Series: Replicated Experiments.

EXPERIMENTS ON CEREALS.

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

Effect of Superphosphate.

Great Harpenden, 1927.

NE

A | B

2U P	2M P	2C	0(*b*)	0(*a*)	0(*b*) P	2S P	1S P
1M P	1C	2S	1S	1U	2C P	2U	2M
0(*a*) P	0(*d*) P	1U P	0(*c*)	1M	1C P	0(*c*) P	0(*d*)
2U	0(*a*)	0(*d*)	2(*c*) P	0(*a*) P	2C	2S	0(*d*) P
0(*b*) P	0(*c*) P	1S P	1M	1S	2U P	0(*b*)	1M P
1U	1C P	2S P	2M	2M P	1C	1U P	0(*c*)

C | D

System of Replication.—4 randomised blocks of 12 plots each.

Area of plot $\frac{1}{40}$ acre.

O.—No Nitrogen.

U, C, S, M.—Nitrogen in form of Urea, Cyanamide, Sulphate and Muriate of Ammonia.

1, 2.—Single and double dressings at the rate of 1 and 2 cwts. per acre. S/Amm or its equivalent.

P.—Superphosphate at the rate of 3 cwts. per acre.

Manures applied March 28-29.

Barley sown April 4-6, harvested Sept. 6-7.

Actual Weights in lb.—Total Grain.

Blocks.	0(*a*)	0(*b*)	0(*c*)	0(*d*)	1U	1C	1S	1M	2U	2C	2S	2M
A	35.5	23.25	32.5	39.125	42.0	45.625	35.125	53.875	60.0	46.625	36.625	67.75
B	33.5	37.125	31.25	29.875	42.875	51.5	58.875	45.75	62.25	55.375	67.0	65.25
C	34.375	43.0	34.625	30.25	50.125	53.625	44.875	46.0	59.375	49.375	58.0	67.75
D	30.5	32.375	33.375	28.5	48.563	51.125	51.625	56.625	64.0	49.5	50.0	63.0

Actual Weights in lb.—Total Straw.

A	45.5	29.0	43.5	45.5	56.5	50.0	46.5	59.5	69.0	52.0	52.0	73.5
B	41.0	45.5	47.5	46.5	50.0	56.0	69.5	49.5	70.5	66.0	72.0	80.5
C	40.5	51.0	51.5	36.5	55.0	59.0	56.5	53.0	66.0	57.0	70.0	74.5
D	38.5	48.0	46.5	34.5	63.0	68.5	55.5	61.5	67.0	57.0	55.0	74.0

https://doi.org/10.23637/ERADOC-1-85

Barley, 1927 (cont.)

(1) Summary of Average Yields, Separate Treatments.

Average Yield in cwts. per acre.		No Nitrogen.	Single Dressing.				Double Dressing.				Stand'rd Error.
			S/Amm.	M/Amm.	Cyan.	Urea.	S/Amm.	M/Amm.	Cyan.	Urea.	
Grain	without phosphate	11.1	15.5	16.4	17.3	16.6	15.5	23.8	17.2	21.7	1.21
	with phosphate	12.5	18.5	19.7	18.8	16.2	22.3	23.3	18.7	22.1	
Straw	without phosphate	14.8	18.2	18.3	21.2	18.8	19.1	27.7	19.5	24.4	1.50
	with phosphate	16.0	22.5	21.6	20.5	21.3	25.4	26.3	22.0	24.3	

NOTE.—The phosphate differences are increased in the case of the sulphate and cyanamide plots, and decreased in the case of the muriate and urea plots, by soil differences.

(2) Summary of Significant Results.

Average of all Nitrogenous Treatments.	Without Super.	With Super.	Mean.	Standard Error.
Grain, cwts. per acre ...	15.7	17.5	16.6	0.35
Grain, per cent. ...	94.7	105.3	100.0	2.10
Straw, cwts. per acre ...	18.9	20.7	19.8	0.43
Straw, per cent. ...	95.4	104.6	100.0	2.19

Average of plots with and without Super.		Grain, cwts. per acre.				Grain, per cent.			
		S/Amm.	M/Amm.	Cyan.	Urea.	S/Amm.	M/Amm.	Cyan.	Urea.
Quantity of Nitrogen	0	11.8				71.2			
	1	17.0	18.1	18.0	16.4	102.5	108.9	108.7	98.8
	2	18.9	23.5	17.9	21.9	113.9	142.0	108.1	132.2
		Straw, cwts. per acre.				Straw, per cent.			
Quantity of Nitrogen	0	15.4				77.9			
	1	20.4	20.0	20.8	20.0	103.9	98.2	103.2	102.3
	2	22.2	27.0	20.7	24.3	113.4	137.8	105.7	124.1

Standard Errors.—Grain 0.85 cwts. or 5.15 per cent.; Straw 1.06 cwts. or 5.37 per cent.

Significant response to Superphosphate in both Grain and Straw. Big response to single and double nitrogen. No differences between the equivalent nitrogenous manures appear in the single dressing, but the double dressing gives no further increase with Cyanamide and very little with sulphate.

https://doi.org/10.23637/ERADOC-1-85

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

Effect of Superphosphate.

Long Hoos, 1928.

W.N.W.

A												B											
1S P	0 (a)	1U	0 (c) P	0 (b)	1C P	2C P	2U	2M	1M	2S P	0 (d) P	1M P	2S	2M P	1S	0 (c) P	2C	0 (a)	0 (b)	0 (d) P	1U P	1C	2U P

C												D											
2M P	0 (c) P	0 (a)	2U P	2C	1U P	1C	0 (b)	0 (d) P	1M P	1S	2S	2U	0 (a)	1M	1S P	1U	0 (c) P	1C P	2S P	0 (b)	2C P	2M	0 (d) P

E												F											
2M	0 (a)	0 (b)	1U	0 (c) P	2C P	2U	1C P	1M	1S P	2S P	0 (d) P	2M	1S P	2C P	0 (c) P	0 (d) P	0 (a)	2S P	2U	1C P	0 (b)	1U	1M

G												H											
0 P	1M P	2C	0 P	2M P	1U P	0	2S	2U P	1S	0	1C	0 P	1C	2U P	1U P	0 P	2M P	1S	0	2C	1M P	0	2S

System of Replication.—8 Randomised Blocks of 12 plots each. Area of plot $\frac{1}{40}$ acre. 0=No Nitrogen ; U, C, S, M= Nitrogen in form of Urea, Cyanamide, Sulphate and Muriate of Ammonia ; 1, 2=Single and double dressings at the rate of 1 and 2 cwt. per acre, S/Amm. or its equivalent ; P=Superphosphate at the rate of 3 cwt. per acre. Variety : Spratt Archer. Manures applied March 28. Barley sown March 28, harvested August 24.

Actual Weights in lb.—Total Grain.

	Without Phosphate.		With Phosphate.									
Block.	0(*a*)	0(*b*)	0(*c*)	0(*d*)	1U	1C	1S	1M	2U	2C	2S	2M
A	47.5	43.5	47.0	32.75	53.25	49.0	64.5	44.25	58.25	58.5	45.75	46.25
B	29.5	32.5	28.0	32.75	41.25	41.25	36.25	37.5	38.0	47.5	35.0	43.0
C	36.75	38.25	53.5	42.25	48.75	43.0	53.5	56.75	37.0	45.5	57.25	54.0
D	42.0	44.0	43.25	40.75	56.0	48.25	53.75	49.5	56.5	52.75	56.0	49.5
E	44.75	45.75	49.25	36.75	57.5	57.75	56.25	54.5	63.75	66.5	55.75	65.5
F	35.5	40.0	40.5	41.0	43.0	46.5	45.25	45.5	45.25	51.5	45.5	54.5
G	40.0	35.0	44.0	36.25	50.0	42.75	45.0	51.25	53.0	47.0	46.5	53.75
H	39.25	40.75	37.25	41.25	42.75	46.0	43.5	48.0	49.75	51.0	46.0	53.5

Actual Weights in lb.—Total Straw.

	Without Phosphate.		With Phosphate.									
Block.	0(*a*)	0(*b*)	0(*c*)	0(*d*)	1U	1C	1S	1M	2U	2C	2S	2M
A	76.5	65.5	71.0	64.75	85.75	81.0	106.5	90.25	111.25	107.0	100.75	112.25
B	53.5	59.0	51.0	61.75	67.25	68.25	75.75	78.0	77.5	93.0	87.5	83.0
C	58.75	58.25	90.5	64.25	78.25	69.5	80.0	86.75	61.0	76.0	94.25	92.0
D	55.5	66.0	68.75	59.25	91.5	71.25	86.25	77.0	88.5	86.75	92.5	85.0
E	79.25	70.75	74.75	74.75	89.0	97.25	96.75	89.5	97.25	99.5	104.25	112.0
F	59.5	76.0	76.0	67.5	89.5	93.0	97.25	86.5	96.25	106.5	94.0	109.5
G	81.0	70.5	84.0	67.25	107.0	80.75	90.5	105.75	106.25	99.5	107.0	106.25
H	67.75	69.75	65.75	76.25	88.25	84.5	87.0	88.0	97.5	89.5	92.5	112.0

https://doi.org/10.23637/ERADOC-1-85

Barley, 1928 (cont.)

(1) Summary of Average Yields, Separate Treatments.

Average Yield in cwt. per acre.		No Nitrogen	Single Dressing.				Double Dressing.				Mean.	Standard Error.
			S/Am.	M/Am.	Cyan.	Urea.	S/Am.	M/Am.	Cyan.	Urea.		
Grain	without phosphate	14.2	15.9	17.3	15.4	18.7	16.5	19.3	17.1	20.0	16.4	0.84
	with phosphate	14.4	19.6	17.3	18.0	16.3	18.1	18.2	20.5	15.9	16.8	
Straw	without phosphate	23.8	29.8	30.6	27.1	31.8	34.0	37.4	32.0	35.1	29.4	1.32
	with phosphate	24.9	34.5	32.0	30.6	30.4	35.0	35.1	35.7	30.6	30.3	

NOTE.—The phosphate differences are increased in the case of the sulphate and cyanamide plots, and decreased in the case of the muriate and urea plots, by soil differences.

(2) Summary of Significant Results.

Average of all Nitrogenous Treatments.	Without Super.	With Super.	Mean.	Standard Error.
Grain, cwts. per acre ...	16.4	16.8	16.6	0.24
Grain, per cent. ...	98.8	101.2	100.0	1.46
Straw, cwts. per acre ...	29.4	30.3	29.9	0.38
Straw, per cent. ...	98.5	101.5	100.0	1.28

Average of plots with and without Super.		Grain, cwts. per acre.				Grain, per cent.			
		S/Amm.	M/Amm.	Cyan.	Urea.	S/Amm.	M/Amm.	Cyan.	Urea.
Quantity of Nitrogen	0	14.3				86.1			
	1	17.8	17.3	16.7	17.5	107.0	104.1	100.7	105.5
	2	17.3	18.7	18.8	17.9	104.3	112.9	113.0	107.9
Mean ...		16.6				100.0			
Standard error		0.59				3.58			
		Straw, cwts. per acre.				Straw, per cent.			
Quantity of Nitrogen	0	24.4				81.7			
	1	32.1	31.3	28.8	31.1	107.6	104.9	96.5	104.1
	2	34.5	36.2	33.8	32.8	115.5	121.4	113.3	110.0
Mean ...		29.9				100.0			
Standard error		0.94				3.14			

Significant response in both grain and straw to the single dressing, and a further response to the double dressing in the case of muriate and cyanamide. There are no differences between the equivalent nitrogenous manures in the case of grain, but with straw the cyanamide plots are significantly below the sulphate and muriate plots. The response to superphosphate is not significant, but there is evidence that it improved the yield of straw, and that the muriate plots responded better than the urea plots.

https://doi.org/10.23637/ERADOC-1-85

Nitrogenous Fertilisers as Top Dressings :

Sulphate of ammonia.
Muriate of ammonia.

Each in single and double dressings (1 and 2 cwt. per acre Solidus Amm.).
Applied : (*a*) Early (April 11th) ; (*b*) Late (May 30th).

Wheat : Great Knott, 1927.

NW

P			Q		
1ML	2ME	0A	2ME	0A	0B
0B	2SL	1SE	1ML	1SE	2SL
1ME	0C	2SE	1ME	1SL	0C
0D	2ML	1SL	2ML	0D	2SE
1SE	2SL	0A	0A	2SL	1ML
0B	1ML	2ME	2ME	1SE	0B
0C	2ML	1SL	1SL	2SE	2ML
1ME	2SE	0D	0C	0D	1ME
R			S		

System of Replication.—48 plots in 8 randomised blocks of 6 plots each.

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

0.—No top dressing.

1, 2.—Dressing of 1 and 2 cwt. Sulphate of Ammonia (S) or equivalent Muriate of Ammonia (M) per acre.

E.—Early. 50 per cent. plants tillered (April 11).

L.—Late. Shoot number reached maximum (May 30).

Wheat sown Oct. 7, 1926 ; harvested Aug. 24-25, 1927.

Actual Weights in lb.—Total Grain.

Blocks.	0A	0B	0C	0D	1SE	1SL	1ME	1ML	2SE	2SL	2ME	2ML
P	71.375	63.5	47.625	42.5	61.25	56.5	57.0	71.125	59.875	68.125	70.25	58.375
Q	79.0	67.25	50.375	68.0	74.5	54.375	47.375	62.5	74.875	59.125	71.0	76.75
R	71.5	56.0	65.375	71.25	71.75	63.875	70.125	71.5	76.875	75.25	86.5	72.375
S	64.75	82.5	84.0	76.125	89.5	89.125	89.75	90.625	94.375	97.0	72.875	86.25

Actual Weights in lb.—Total Straw.

P	118.5	118.5	107.0	88.0	147.0	123.5	118.5	135.5	124.5	132.0	147.0	120.0
Q	137.0	126.5	98.0	118.0	131.0	107.0	106.5	123.0	144.5	113.0	147.5	131.5
R	133.0	126.0	129.5	154.5	132.5	152.5	160.5	147.5	174.0	139.5	169.5	155.5
S	122.5	168.5	161.5	143.0	165.0	161.5	157.0	154.0	181.5	163.0	155.5	143.0

(1) Summary of Average Yields, Separate Treatments.

Average Yield per acre.	No Top Dressing	Single S/Amm. early.	Single S/Amm. late.	Single M/Amm. early.	Single M/Amm. late.	Double S/Amm. early.	Double S/Amm. late.	Double M/Amm. early.	Double M/Amm. late.
Grain, cwt.	23.7	26.5	23.6	23.6	26.4	27.3	26.7	26.8	26.2
Straw, cwt.	45 8	51.4	48.6	48.4	50.0	55.8	48.9	55.3	49.1

Erratum :

On line 4 for "Solidus Amm." read "Sulphate of Ammonia."

Wheat, 1927 (cont.)

(2) Summary of Significant Results.

Average Yield per acre.	O	Single.	Double.	Mean.	Standard Error. (*a*)	Early Sulphate.	Early Muriate.	Late Sulphate.	Late Muriate.	Single Early.	Double Early.	Single Late.	Double Late.	Standard Error. (*b*).
Grain, cwt. ...	23.7	25.0	26.8	25.2	0.73	26.9	25.2	25.2	26.3	25.1	27.1	25.0	26.5	1.03
Grain, per cent. ...	94.1	99.4	106.4	100.0	2.90	107.0	100.2	100.0	104.6	99.6	107.6	99.3	105.3	4.09
Straw, cwt. ...	45.8	49.6	52.3	49.2	1.05	53.6	51.9	48.8	49.6	49.9	55.5	49.3	49.0	1.49
Straw, per cent. ...	93.0	100.8	106.2	100.0	2.14	108.9	105.4	99.1	100.7	101.4	112.9	100.2	99.6	3.02

(*a*) Refers to means of 16 plots.
(*b*) Refers to means of 8 plots.

Significant response to double top dressing in the grain, and to both dressings in the straw. With straw the double dressing produced no further increase when applied late.

Wheat : Pastures Field, 1928.

S.E.

Yeoman II **Squareheads Master** **Swedish Iron**

A 1st | D 3rd | G 3rd

4	2	8	5	6	1	7	3	6	7	3	8	4	1	5	2	4	5	8	2	7	3	6	1

B 2nd | E 2nd | H 1st

7	8	2	3	4	1	6	5	6	5	1	4	8	2	3	7	1	6	2	4	8	7	3	5

C 3rd | F 1st | J 2nd

5	6	4	3	8	7	1	2	4	3	2	8	7	6	5	1	8	7	3	1	6	2	5	4

System of Replication : 9 randomised blocks (3 to each variety) of 8 plots each.
Plots $\frac{1}{40}$ acre.
Sulphate of Ammonia at the rate of 1 cwt. per acre. Muriate of Ammonia equivalent to Sulphate.
1, 2=No Top Dressing.
3=Sulphate Early.
4=Muriate Early.
5=Sulphate Late.
6=Muriate Late.
7=Sulphate Early and Late.
8=Muriate Early and Late.
7 and 8 thus had double the amount of Nitrogen given to 3, 4, 5 and 6.
1st, 2nd, 3rd : Time of application of Top Dressing.
1st Early : Applied March 7.
2nd Early : Applied March 14.
3rd Early : Applied March 21st.
Late Dressings applied 6 weeks after Early.
Wheat sown October 21, 1927; harvested August 17, 1928.

Actual Weights in lb.—Total Grain.

Variety.	Block.	Time.	1	2	3	4	5	6	7	8	Average in cwt. per acre.	
Yeoman II.	A	1st	77.25	80.25	94.75	87.0	82.0	86.0	87.75	90.75	30.6	27.7
	B	2nd	79.0	79.5	80.0	80.0	75.5	66.0	83.25	85.25	28.1	
	C	3rd	60.75	68.5	60.75	64.75	92.0	86.75	50.75	65.75	24.6	
Squareheads Master	D	3rd	79.75	67.5	60.75	74.5	75.75	72.0	57.25	77.0	25.2	24.6
	E	2nd	61.25	67.0	73.75	66.75	62.75	69.25	77.75	79.75	24.9	
	F	1st	60.5	55.5	50.5	66.5	75.75	75.25	71.25	74.5	23.6	
Swedish Iron	G	3rd	58.25	64.0	63.25	88.75	83.75	60.25	64.0	79.75	25.1	22.9
	H	1st	48.0	49.25	55.75	50.0	68.0	69.0	62.25	61.25	20.7	
	J	2nd	55.25	58.5	59.5	76.75	68.25	64.5	66.5	66.5	23.0	
Average in cwt. per acre ...			23.2		23.8	26.0	27.1	25.8	24.6	27.0	25.1	

Actual Weights in lb.—Total Straw.

Variety.	Block	Time.	1	2	3	4	5	6	7	8	Average in cwt. per acre.	
Yeoman II.	A	1st	96.75	97.75	125.25	114.0	108.5	114.0	114.25	116.25	39.6	35.7
	B	2nd	107.0	96.0	100.0	99.5	97.0	74.5	112.75	111.25	35.6	
	C	3rd	67.25	89.5	89.25	75.25	133.0*	117.25	60.25	84.25	32.0	
Squareheads Master	D	3rd	95.75	97.0	92.25	101.5	100.25	105.0	95.75	139.0	36.9	35.2
	E	2nd	84.75	92.0	119.25	97.25	87.75	101.75	100.75	114.25	35.6	
	F	1st	88.5	73.0	67.0*	100.5	107.25	94.75	107.75	103.0	33.1	
Swedish Iron	G	3rd	71.25	70.0	81.75	102.25	107.25	77.75	103.0	107.25	32.2	28.8
	H	1st	48.5	50.25	68.75	52.5	87.5	77.0	85.25	76.75	24.4	
	J	2nd	71.0	73.0	76.5	97.25	96.25	86.5	84.5	80.5	29.7	
Average in cwt. per acre			29.2		32.5	33.3	36.7	33.7	34.3	37.0	33.2	

* Estimated Figures.

(1) Summary of Average Yields, Separate Treatments.

	Variety.	No Top Dressing.	Sulphate of Amm'nia Early.	Muriate of Amm'nia Early.	Sulphate of Amm'nia Late.	Muriate of Amm'nia Late.	Sulphate of Amm'nia Early and Late.	Muriate of Amm'nia Early and Late.
Grain, cwt. per acre	Yeoman II ...	26.5	28.0	27.6	29.7	28.4	26.4	28.8
	Squareheads Master	23.3	22.0	24.7	25.5	25.8	24.6	27.5
	Swedish Iron ...	19.8	21.2	25.7	26.2	23.1	22.9	24.7
Straw, cwt. per acre	Yeoman II ...	33.0	37.4	34.4	40.3	36.4	34.2	37.1
	Squareheads Master	31.6	33.2	35.6	35.1	35.9	36.2	42.4
	Swedish Iron ...	22.9	27.0	30.0	34.6	28.7	32.5	31.5

(2) Summary of Significant Results, averaging varieties.

Average Yield per acre.	No Top Dressing.	Early Top Dressing.	Late Top Dressing.	Early and Late Top Dressing.	Mean.	Standard Error.
Grain, cwt. ...	23.2	24.9	26.4	25.8	25.1	0.74
Grain, per cent.	92.5	99.2	105.4	102.9	100.0	2.94
Straw, cwt. ...	29.2	32.9	35.2	35.6	33.2	1.22
Straw, per cent.	87.7	99.1	105.9	107.3	100.0	3.67

The late dressing produced a significant response in grain and straw, while the difference between the muriate and sulphate plots is not significant. There is evidence that the straw responded to some extent to the early dressing. The experiment does not permit of valid conclusions being drawn as to differences between varieties nor between the three dates of the early dressing.

https://doi.org/10.23637/ERADOC-1-85

Barley: Nitrogenous Top Dressing, Sulphate and Muriate of Ammonia.

Great Harpenden, 1927.

S.S.W.

	Plot 1.	Plot 2.	Plot 3.	Plot 4.	Plot 5.	Plot 6.
Area in acres... ...	1.28	2.40	2.12	2.18	2.10	2.16
Yield of grain in lbs.	920	2292	1983	2187	1359	1631
Yield in cwt./acre ...	6.42	8.53	8.35	8.96	5.78	6.74

Barley sown April 4-6; harvested September 6-7.
Plots 1 and 5=No manure.
Plots 2 and 4=Sulphate of Ammonia at the rate of 1 cwt. per acre } applied June 10-11.
Plots 3 and 6=Muriate of Ammonia equivalent of above
No straw weights taken.

Summary of Results.

Average Yield of Grain.	Control.	Muriate.	Sulphate.	Mean.
lb. per acre	682.94	845.24	979.10	835.76
cwt. per acre	6.10	7.55	8.74	7.46
Per cent.	81.7	101.1	117.2	100.0

Barley : Nitrogenous Top Dressing, Nitrochalk.
Long Hoos, 1928.

E.S.E.

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

TREATMENTS :
A = No Top Dressing.
B = Early Top Dressing of Nitrochalk, May 22nd.
C = Middle Top Dressing of Nitrochalk, June 4th.
D = Late Top Dressing of Nitrochalk, June 19th.
Rate of application = 2 cwt. per acre.

SYSTEM OF REPLICATION :—4 randomised blocks of 4 plots each.
Area of each plot = $\frac{1}{40}$ acre.
Barley sown, March 28 ; harvested August 24, 1928.
Variety : "Standwell."

Actual Yields in lb.

Block.	Grain.				Straw.			
	A	B	C	D	A	B	C	D
I. ...	36.0	35.5	39.0	41.25	91.0	96.5	94.0	90.75
II. ...	43.5	41.75	39.25	39.0	85.5	88.25	82.75	77.5
III. ...	45.5	51.5	51.75	48.0	73.5	92.5	96.25	77.0
IV. ...	49.0	43.5	54.75	47.75	87.0	79.5	86.25	85.25

Summary of Results.

Average Yield.	No Top Dressing.	Early Top Dressing.	Middle Top Dressing.	Late Top Dressing.	Mean.	Standard Error.
Grain, cwt. per acre	15.5	15.4	16.5	15.7	15.8	0.61
Grain, per cent. ...	98.4	97.5	104.5	99.6	100.0	3.85
Straw, cwt. per acre ...	30.1	31.9	32.1	29.5	30.9	1.11
Straw, per cent. ...	97.4	103.1	103.9	95.6	100.0	3.59
Per cent. Nitrogen in dry matter of grain ...	2.075	2.118	2.110	2.160	2.116	0.0264

No significant response to treatment in grain and straw. Late top dressing gave significantly higher percentage of nitrogen in dry matter of grain than the control.

POTATOES.

Nitrogenous Fertiliser : Sulphate of Ammonia.
Potassic Fertilisers : Sulphate of Potash.
Muriate of Potash.
30 per cent. Potash Manure Salts.
Each in single and double dressings.

Long Hoos, 1927.

W.N.W

	A			B			C		
	N4 0	N2 0	N2 P4	N2 0	N4 P2	0 0	N2 0	0 P4	N2 M2
	0 M4	N2 S2	N4 M2	N4 P4	N4 0	N2 S4	N2 M4	N4 S4	0 0
	N4 S4	0 0	0 P2	0 S2	N2 M2	0 M4	N4 0	N4 S2	0 P2
	N2 P2	0 S2	N4 0	N2 P2	N4 S2	N4 0	N4 S4	N2 S2	0 M2
D	N4 M2	N2 P4	0 S4	N2 P4	N2 0	0 M2	0 P4	N2 0	N2 M4
	N4 M4	N2 0	0 0	N4 M4	0 0	0 S4	0 0	N4 0	N4 P2
	0 0	0 M2	N4 0	N2 0	N2 M4	N4 P4	0 P4	N2 S4	N4 M2
	0 M4	N2 0	N2 S2	N4 S2	0 P2	N4 0	0 0	0 S2	N4 0
	N4 P4	N4 P2	N2 S4	N2 M2	0 0	0 S4	N2 P2	N2 0	N4 M4
	G			H			J		

F

Variety : Arran Comrade.

System of Replication : 9 randomised blocks of 9 plots each.

Area of plot $\frac{1}{40}$ acre.

Quantities : Sulphate of Ammonia at the rate of 2 and 4 cwt. per acre. Potash at the rate of 2 and 4 cwt. per acre as Sulphate or its equivalent as Muriate or Potash Manure Salts.

O = No artificial manure.
N = Nitrogen as Sulphate of Ammonia.
S = Sulphate of Potash.
M = Muriate of Potash.
P = Potash Manure Salts.

All plots had 10 tons F.Y.M. applied May 14-16

Artificials applied May 17-18.

Potatoes planted May 23-25 ; Lifted October 6-24.

Actual Weight in lb.

Nitrogen	Potash	A	B	C	D	E	F	G	H	J
Quantities										
0	0	356.5	382.0	348.5	395.0	366.5	349.5	337.5	411.5	351.5
0	2	365.0	401.0	354.0	357.0	360.5	361.0	345.0	395.5	344.0
0	4	308.5	364.0	335.5	362.5	395.5	319.0	302.0	401.5	333.0
2	0	379.5	379.0	380.5	394.5	409.5	402.5	377.0	446.5	389.5
2	2	421.0	420.0	389.0	404.5	408.5	411.0	467.5	474.0	400.5
2	4	382.5	424.5	409.5	323.5	403.5	369.5	463.5	455.0	405.0
4	0	333.5	413.5	399.0	412.5	428.0	400.5	440.0	411.5	369.0
4	2	430.5	381.0	408.0	440.0	438.5	358.5	388.0	473.0	390.5
4	4	403.0	396.0	436.0	436.5	465.5	412.0	356.5	405.5	436.0

https://doi.org/10.23637/ERADOC-1-85

(1) Summary of Average Yields, Separate Treatments.

Average Yield in tons per acre.		No Nitrogen.			2 cwt. S/Amm.			4 cwt. S/Amm.		
Quality of Potash.		Sulphate	Muriate	P.M.S.	Sulphate	Muriate	P.M.S.	Sulphate	Muriate	P.M.S.
Quantity of Potash in cwt. per acre S/Pot.	0	6.54			7.06			7.16		
	2	6.56	6.35	6.63	7.74	7.64	7.22	7.85	7.51	6.71
	4	6.90	5.80	5.88	7.70	7.35	6.60	7.45	7.96	6.89

Standard Error 0.245 tons.

(2) Summary of Significant Results.

(a) Effect of Potassium Salts.

		Average Yield in tons per acre.			Average Yield, per cent.		
		Sulphate.	Muriate.	Potash Manure Salts.	Sulphate.	Muriate.	Potash Manure Salts.
Amount of Potash in cwt. per acre S/Pot. ...	0		6.92			98.9	
	2	7.38	7.16	6.86	105.5	102.3	98.0
	4	7.35	7.04	6.46	105.0	100.5	92.2

Standard Error 0.141 tons, or 2.02 per cent.

(b) Effect of Sulphate of Ammonia.

		Average Yield in tons per acre.			Average Yield, per cent.		
		Amount of Nitrogen.			Amount of Nitrogen.		
		0	2	4	0	2	4
Amount of Potash	0	6.54	7.06	7.16	93.5	100.9	102.2
	2	6.51	7.53	7.36	93.0	107.6	105.1
	4	6.19	7.22	7.43	88.5	103.1	106.2

Standard Error 0.141 tons or 2.02 per cent.

Average Yield.	Quantity of S/Am.			Quantity of Potash.			Mean Yield.	(*a*) Standard Error.	Sulphate.	Muriate.	Potash Manure Salts.	(*b*) Standard Error.
	0	2	4	0	2	4						
Tons per acre	6.42	7.27	7.32	6.92	7.13	6.95	7.00	0.082	7.37	7.10	6.66	0.100
Per cent. ...	91.7	103.8	104.5	98.9	101.9	99.2	100.0	1.17	105.2	101.4	95.1	1.43

(*a*) Refers to means of 27 plots. (*b*) Refers to means of 18 plots.

The Potash Manure Salts depress the yield slightly in the single dressing and significantly in the double dressing ; a similar but slighter effect appears with Muriate. In both cases the effect is least on the high Nitrogen plots. The Sulphate of Potash causes no depression, although the higher dressing gives no further increase in yield.

POTATOES.

Nitrogenous Fertiliser : Sulphate of Ammonia.
Potassic Fertiliser : Sulphate of Potash.
Each in single and double dressings.

Superphosphate.

Great Harpenden, 1928.

N.E.

A			B			C		
3O	6P	9O	9P	6P	5O	2O	9P	4O
3P	6O	9P	9O	6O	5P	2P	9O	4P
1O	7O	2O	8O	4O	1O	7O	8P	5P
1P	7P	2P	8P	4P	1P	7P	8O	5O
4O	8P	5O	7O	2P	3O	1P	3O	6P
4P	8O	5P	7P	2O	3P	1O	3P	6O

System of Replication : Experiment laid down as in 1927. The portion harvested consisted of 3 randomised blocks of 9 plots each divided into 2 sub-plots.

Area of whole plot : $\frac{1}{45}$ acre.

O, P = No Phosphate and Superphosphate at the rate of 3 cwt. per acre. Sulphate of Ammonia at the rate of 0, $1\frac{1}{2}$ and 3 cwt. per acre, and Potash at the rate of 0, 1 and 2 cwt. per acre Sulphate of Potash in all combinations. All plots received 10 tons F.Y.M. per acre.

Variety : Ally.

Artificial Manures applied April 16-17.

Potatoes planted April 17-19 ; lifted October 19.

Key to Treatments.

Treatment No.	1	2	3	4	5	6	7	8	9
S/Amm. ...	0	$1\frac{1}{2}$	3	0	$1\frac{1}{2}$	3	0	$1\frac{1}{2}$	3
Potash	0	0	0	1	1	1	2	2	2

Actual Weights in lb. Phosphate Sub-plots.

Block.	1	2	3	4	5	6	7	8	9
A	139.0	219.0	200.5	145.0	193.5	260.5	174.5	213.0	246.5
B	197.5	205.0	206.0	182.5	254.5	282.0	143.0	213.5	265.5
C	156.0	229.5	210.0	245.5	226.5	282.5	210.0	229.5	281.5

Actual Weights in lb. No Phosphate Sub-plots.

Block.	1	2	3	4	5	6	7	8	9
A	142.0	197.5	195.5	141.5	205.5	201.0	149.5	185.0	240.0
B	168.5	180.0	210.0	180.5	227.0	256.0	159.0	192.0	224.5
C	144.5	251.5	191.5	247.0	251.0	271.5	182.5	230.0	263.0

(1) Summary of Average Yields, Separate Treatments.

Tons per acre.		Without Superphosphate.			With Superphosphate.		
		No S/Amm.	1½ cwt. S/Amm.	3 cwt. S/Amm.	No S/Amm.	1½ cwt. S/Amm.	3 cwt. S/Amm.
Quantity of Potash in cwt. per acre S/Pot. ...	0	6.09	8.42	8.00	6.60	8.75	8.26
	1	7.62	9.15	9.76	7.67	9.03	11.05
	2	6.58	8.13	9.74	7.06	8.79	10.63

(2) Summary of Significant Results.

Average Yield.	Without Super.	With Super.	Mean.	Standard Error.
Tons per acre ...	8.17	8.65	8.41	0.11
Per cent. ...	97.1	102.9	100.0	1.29

		Average Yields tons per acre.			Per cent.		
		Quantity of S/Amm.			Quantity of S/Amm.		
		0	1½	3	0	1½	3
Quantity of Potash in cwt. per acre S/Pot.	0	6.34	8.59	8.13	75.5	102.2	96.7
	1	7.65	9.09	10.40	91.0	108.2	123.7
	2	6.82	8.46	10.19	81.1	100.6	121.1
		Standard error 0.32 tons			Standard error 3.84 per cent.		

Significant response to all three manures. No further response to the higher dressing of Potash, or to the higher nitrogenous dressing in the absence of Potash.

SUGAR BEET.

Nitrogenous Fertilisers : Sulphate of Ammonia applied with seed.
Nitrate of Soda as top dressings at rates of 1, 2 and 3 cwt. per acre.
Cyanamide, applied 1 week before sowing at three rates.

Potassic Fertilisers : Muriate of Potash.
Potash Manure Salts.

Spacing of Plants.

Long Hoos, 1927

(a) **Manuring Experiment.**

N.W.

A — B — C

S, N2 L	C4 K	S, 0 L	C3 K	S, N5 L	O, N3 L	O, 0 K	S, N1 K	C2 K	O, N1 L	S, 0 L	C4 K
S, N3 K	C1 L	O, N1 K	O, N3 L	O, N1 K	S, 0 K	C3 L	C2 L	C1 L	S, N1 K	S, N3 K	O, 0 L
O, 0 L	S, N1 K	C2 L	O, N2 K	O, N2 K	S, N2 K	C1 L	C4 L	O, N2 L	S, N2 K	C3 K	O, N3 L
S, N2 K	S, N3 L	C2 K	C3 L	S, N2 L	O, 0 L	C4 K	S, N3 K	O, N3 K	S, N1 L	S, N3 L	O, N1 K
O, N1 L	O, N2 L	O, N3 K	S, 0 K	S, N1 L	O, N2 L	O, N1 L	S, 0 L	S, N2 L	O, N2 K	O, 0 K	C3 L
O 0 K	C1 K	C4 L	S, N1 L	C2 K	O, N3 K	C1 K	C3 K	C1 K	C2 L	C4 L	S, 0 K

D — E — F

SYSTEM OF REPLICATION :
Six randomised blocks of 12 plots each.
Area of plot = .024 acre.
O, : No basal dressing.
, O : No top dressing.
S : Basal dressing of 1 cwt. per acre Sulphate of Ammonia.
C (1, 2, 3, 4) : Basal dressings of Cyanamide equivalent to 1, 2, 3 and 4 cwts per acre Sulphate of Ammonia.
, N (1, 2, 3) : Top dressings of Nitrate of Soda equivalent to 1, 2 and 3 cwt. per acre Sulphate of Ammonia.

Each adjoining pair of plots allotted at random to receive 2 cwt. per acre Muriate of Potash (K) or equivalent Potash Manure Salts (L).

All plots had 8 tons per acre (approx.) of London Refuse.

Cyanamide applied June 1. Other Basal Manures June 8-9. Top Dressing August 10. Seed sown June 16. Pulled November 21—December 10.

https://doi.org/10.23637/ERADOC-1-85

Blocks.	Roots—Actual Weights in lb.											
	0,0	C1	S,0	O,N1	O,N2	O,N3	C2	C3	C4	S,N1	S,N2	S,N3
A	153.5	207.25	199.25	193.75	197.25	204.5	216.0	204.75	227.25	208.0	228.0	200.0
B	159.5	177.75	144.5	152.75	149.75	185.5	199.25	202.5	214.5	197.0	178.25	174.5
C	157.75	173.75	159.0	200.75	167.0	183.25	198.75	132.0	200.25	177.75	163.0	164.25
D	203.5	211.25	189.0	229.0	222.75	198.5	243.25	245.25	208.5	217.25	220.25	245.25
E	180.0	147.5	121.0	153.75	197.5	196.25	197.75	165.25	203.75	215.25	211.75	177.0
F	117.5	118.5	108.5	151.25	137.25	151.75	117.0	155.75	112.5	151.75	141.25	152.0
	Tops—Actual Weights in lb.											
A	479.0	542.0	547.0	564.5	646.0	666.5	656.5	584.5	719.5	612.0	831.0	836.0
B	437.0	451.0	415.5	503.0	596.0	715.5	548.5	565.5	649.5	621.5	559.0	734.5
C	455.0	465.0	544.5	664.0	564.0	634.5	578.5	455.0	644.5	596.0	580.0	597.0
D	605.0	566.0	506.0	766.0	737.5	738.5	703.0	716.5	735.0	678.5	739.5	822.5
E	473.0	382.5	419.5	424.5	655.5	738.5	643.5	548.0	597.0	711.0	774.0	652.0
F	357.5	358.0	366.5	477.5	455.0	542.5	372.0	496.5	369.0	482.5	475.5	547.0

Summary of Results, averaging the Nitrogenous Treatments.

Average Yield.	Muriate of Potash.	Potash Manure Salts	Mean.	Standard Error.
Roots, tons per acre ...	3.30	3.45	3.38	0.05
Roots, per cent.	97.7	102.3	100.0	1.48
Tops, tons per acre ...	10.60	11.04	10.82	0.161
Tops, per cent.	98.0	102.0	100.0	1.49

Summary of Results, averaging the Potash Equivalents.

		Average Yield in tons per acre.				Average Yield per cent.			
		Top Dressing in cwt. per acre S/Amm.*				Top Dressing in cwt. per acre S/Amm.			
		0	1	2	3	0	1	2	3
Roots	No Basal	3.01	3.35	3.32	3.47	89.2	99.3	98.4	102.8
	Cyanamide	3.21	3.63	3.43	3.62	95.1	107.6	101.5	107.1
	Sulphate of Ammonia ...	2.86	3.62	3.54	3.45	84.6	107.2	104.9	102.2
Tops	No Basal	8.70	10.54	11.33	12.51	80.4	97.4	104.7	115.6
	Cyanamide	8.57	10.86	10.44	11.52	79.2	100.3	96.4	106.4
	Sulphate of Ammonia ...	8.68	11.48	12.27	12.99	80.2	106.0	113.4	120.0

Standard Error : Roots, 0.14 tons or 4.15 per cent ; Tops, 0.48 tons, or 4.45 per cent.

* Cyanamide plots received no Top Dressing, and the columns of the table refer in the case of this manure to dressings equivalent to 1, 2, 3 and 4 cwts. per acre Sulphate of Ammonia.

Potash Manure Salts show significant superiority over Muriate. There is a significant response to single top dressing, only the leaves showing any further response to the highest dressings.

K

SUGAR BEET.—(*Cont.*)

Long Hoos, 1927.

(b) Spacing Experiment.

Strip Totals in lb. (left to right).

	Roots.			Tops.		
Strips	N	M	W	N	M	W
1	494.75	361.75	377.75	1780.5	1269.0	1207.0
2	487.00	439.50	395.25	1458.5	1391.0	1150.0
3	493.25	357.75	408.25	1541.5	1203.0	1200.0
4	490.50	392.75	374.75	1537.5	1230.0	1030.5
5	456.50	319.00	326.25	1645.0	1246.0	1071.0
6	411.75	350.25	337.00	1487.5	1272.0	946.0
7	454.75	299.25	290.75	1178.0	883.5	796.0
8	430.75	314.00	312.25	1435.0	877.0	978.5
9	383.75	305.25	262.00	1179.5	936.0	868.0
10	369.25	304.50	273.75	1152.5	1134.0	863.0
11	340.00	264.25	233.00	1257.0	851.5	761.5
12	394.75	292.25	269.75	1143.0	1030.5	901.0

Manuring as on previous page.

SYSTEM OF REPLICATION: 216 plots, each .008 acre, in sets of 3.

N = 14 in. spacing.
M = 18 in. spacing.
W = 22 in. spacing.

Summary of Results.

Average Yield.	Narrow Spacing.	Medium Spacing.	Wide Spacing.	Mean.	Standard Error.
Roots, tons per acre...	4.04	3.10	2.99	3.38	0.062
Roots, per cent. ...	119.5	91.8	88.6	100.0	1.84
Tops, tons per acre ...	13.02	10.33	9.12	10.82	0.249
Tops, per cent. ...	120.3	95.4	84.3	100.0	2.30

The narrow spacing gives a significantly higher yield than the medium and wide spacings, while with tops the medium spacing also does significantly better than the wide.

https://doi.org/10.23637/ERADOC-1-85

SUGAR BEET.

MANURING.

Nitrochalk as top dressing, applied:—(*a*) early; (*b*) early and late.
Superphosphate.
Muriate of potash and potash manure salts.

CULTIVATION.

Subsoiling. Ridging.

Great Harpenden, 1928.

N.W.

	R	F	F	R	R	F	R	F	R	F	F	R	
I	2	6	1	5	10	9	12	11	4	3	7	8	O
II	1	8	5	9	3	7	11	10	6	4	12	2	S
III	6	3	2	11	5	10	4	7	12	8	1	9	O
IV	7	5	9	12	4	8	6	3	2	1	11	10	S
V	12	4	8	3	11	6	5	1	9	10	2	7	S
VI	8	10	11	7	1	12	2	4	3	5	9	6	O
VII	4	2	3	1	9	5	10	6	7	12	8	11	O
VIII	10	7	12	8	2	11	1	9	5	6	3	4	S
IX	3	12	7	4	8	1	9	2	10	11	6	5	S
X	9	1	10	2	6	4	8	12	11	7	5	3	O
XI	5	11	6	10	7	2	3	8	1	9	4	12	O
XII	11	9	4	6	12	3	7	5	8	2	10	1	S

VARIETY: Dippe.

SYSTEM OF REPLICATION: 12×12 Latin Square.

AREA OF PLOT: .014 acre.

TREATMENTS: Muriate of Potash at the rate of 2 cwt. per acre or equivalent Potash Manure Salts (30%). Superphosphate at the rate of 2 cwt. per acre. Top dressing of Nitrochalk at the rate of 2 cwt. per acre, applied early (June 23), and both early and late (July 21). All plots had basal dressing of 10 tons compost in winter, and 2 cwt. per acre Sulphate of Ammonia with other artificials on May 4.

R, F = Pairs of strips one way allotted at random to ridged and flat seed bed.

S, O = Pairs of strips the other way allotted at random to sub-soiling and "not" sub-soiling. The 12 plots of each treatment had 3 allotted to each of the 4 cultivation treatments.

Seed sown May 5; roots lifted October 26–November 3.

Key to Treatments.

Manure.	1	2	3	4	5	6	7	8	9	10	11	12
Mur./Pot. ...	×		×		×		×		×		×	
P.M.S.		×		×		×		×		×		×
Super			×	×			×	×			×	×
Nitrochalk (early)					×	×	×	×	×	×	×	×
Nitrochalk (late)...									×	×	×	×

SUGAR BEET, 1928 (cont.)

Actual Weights in lb.—Roots.

Row.	1	2	3	4	5	6	7	8	9	10	11	12
I	204.5	238.5	304.5	284.0	289.5	204.0	317.0	364.0	265.5	278.0	236.5	274.0
II	210.5	323.5	327.0	317.5	235.0	286.5	298.5	218.0	336.0	267.5	334.5	292.0
III	239.0	264.5	285.5	333.5	313.5	242.5	293.0	311.0	293.5	295.5	319.0	307.5
IV	303.0	288.5	270.0	264.0	238.5	339.5	253.0	291.5	280.0	336.5	290.0	287.0
V	248.5	279.5	277.0	287.0	302.5	276.5	313.0	281.5	332.0	322.0	252.0	280.0
VI	262.0	340.5	293.0	283.0	279.5	275.0	274.5	284.5	284.5	255.5	272.0	301.0
VII	222.5	207.5	252.5	215.5	290.5	243.0	307.0	292.0	317.0	345.5	291.0	312.0
VIII	302.0	266.5	325.5	361.5	269.5	332.0	180.0	281.0	239.5	232.5	282.5	233.0
IX	256.0	246.5	214.0	273.5	401.0	308.5	231.5	277.0	312.5	290.0	273.5	245.5
X	215.0	305.5	362.0	261.0	365.0	299.5	363.0	369.5	173.0	269.5	324.5	211.5
XI	328.0	290.0	315.0	347.0	270.5	244.0	299.0	281.0	332.5	297.5	244.5	405.5
XII	397.5	335.0	283.5	262.0	272.0	324.5	326.5	311.5	259.5	355.0	272.5	322.5

Actual Weights in lb.—Tops.

Row.	1	2	3	4	5	6	7	8	9	10	11	12
I	304.5	412.0	360.0	324.0	367.0	427.5	380.5	423.0	364.5	360.0	332.5	409.0
II	362.5	331.5	347.0	339.5	390.0	339.0	408.5	412.0	433.0	385.0	432.5	360.5
III	251.5	349.5	344.5	311.5	338.5	389.5	333.0	330.0	340.0	425.0	406.0	353.5
IV	325.0	275.5	306.5	305.5	327.0	355.0	286.5	358.5	430.0	362.0	354.5	367.0
V	273.5	278.0	264.5	389.0	303.5	288.0	304.0	339.0	378.5	348.5	346.5	376.0
VI	311.5	299.0	272.5	239.5	265.0	297.5	341.0	402.0	345.0	388.0	377.0	362.0
VII	298.0	247.0	302.5	330.5	321.0	315.0	330.5	332.5	361.0	385.5	306.5	396.0
VIII	305.5	332.5	358.0	356.5	352.0	359.5	317.0	364.0	333.5	414.5	344.0	397.5
IX	275.5	323.0	319.5	338.5	354.0	345.0	503.5	356.0	325.5	356.0	352.5	441.5
X	335.5	357.0	353.0	275.5	368.5	395.5	357.0	343.0	312.5	467.0	359.5	351.0
XI	358.0	310.5	303.5	300.5	358.5	461.5	396.0	364.5	382.0	473.5	517.5	394.5
XII	409.0	351.0	371.5	433.0	406.5	472.0	459.5	412.5	539.5	387.5	464.0	545.5

(1) Summary of Average Yields—Separate Treatments.

Top Dressing.	0		Early.		Early and Late.	
	Super-phosphate.	No Super-phosphate.	Super-phosphate.	No Super-phosphate.	Super-phosphate.	No Super-phosphate.
Roots, tons per acre.						
Muriate of potash ...	9.33	8.47	9.18	9.37	9.01	9.10
Potash manure salts	9.27	9.00	9.47	8.97	9.22	9.42
Tops, tons per acre.						
Muriate of potash ...	10.37	10.12	11.74	11.03	12.20	12.08
Potash manure salts	10.48	10.27	11.79	11.81	12.63	12.63
Sugar in roots, per cent.						
Muriate of potash ...	17.98	17.82	17.71	17.72	17.20	17.26
Potash manure salts	17.98	17.96	17.58	17.52	17.31	17.30

(2) Summary of Significant Results—Manuring Experiment.

Average Yield.	No Top Dressing.	Early Top Dressing.	Early and Late Top Dressing.	Mean.	Standard Error. (*a*)	Muriate of Potash.	Potash Manure Salts.	No. Super.	Super.	Standard Error. (*b*)
Roots, tons per acre	9.02	9.25	9.19	9.15	0.13	9.08	9.23	9.06	9.25	0.10
Roots, per cent. ...	98.5	101.0	100.4	100.0	1.38	99.2	100.8	99.0	101.0	1.13
Tops, tons per acre	10.31	11.59	12.39	11.43	0.16	11.26	11.60	11.32	11.54	0.13
Tops, per cent. ...	90.2	101.4	108.4	100.0	1.40	98.5	101.5	99.0	101.0	1.14
Sugar percentage	17.94	17.63	17.27	17.61	0.06	17.61	17.61	17.60	17.63	0.05

(*a*) Refers to means of 48 plots. (*b*) Refers to means of 72 plots.

The effect of the nitrogenous top dressing is the only significant result. There was a significant response with tops but not with roots. The application of top dressing depressed the sugar content significantly.

https://doi.org/10.23637/ERADOC-1-85

SUGAR BEET. Great Harpenden—*contd.*

Cultivation Experiment.

Column Totals (left to right).

	R	F	F	R	R	F	R	F	R	F	F	R
Roots, lb.	2887	2840.5	3030	3487.5	3478	3392	3895.5	3092	3622	3785.5	3695	4124
Tops, lb.	4428	4686	4755	4481.5	4395.5	4104.5	4233	3963.5	4111.5	4166	4062	4231.5
Number of plants ...	2965	2936	3070	3422	3246	2897	3162	2544	2896	2770	2835	2970

Row Totals (top to bottom).

	O	S	O	S	S	O	O	S	S	O	O	S
Roots, lb.	3260	3446.5	3498	3441.5	3451.5	3405	3296	3305.5	3329.5	3519	3654.5	3722
Tops, lb.	4464.5	4541	4172.5	4053	3889	3900	3926	4234.5	4290.5	4275	4620.5	5251.5
Number of plants ...	2982	3025	2953	3081	2998	2853	2861	3016	3022	2962	2937	3023

Summary of Results—Cultivation Experiment.

Average Yield.	Ridged.	Flat.	Standard Error.	Not Sub-soiled.	Sub-soiled.	Standard Error.	Mean.
Roots, tons per acre ...	9.52	8.78	0.27	9.14	9.17	0.10	9.15
Roots, per cent. ...	104.0	96.0	2.94	99.8	100.2	1.06	100.0
Tops, tons per acre...	11.46	11.40	0.20	11.23	11.63	0.21	11.43
Tops, per cent. ...	100.3	99.7	1.72	98.3	101.7	1.85	100.0
Roots,number per acre	18513	16917	369.4	17409	18021	80.0	17715
Roots,number per cent.	104.5	95.5	2.09	98.3	101.7	0.45	100.0

Ridged beats flat significantly in the case of roots, an effect due to increased number. Sub-soiling produced a significantly larger number of roots, but this was not reflected in an increased yield.

Swedes : Comparison of Phosphatic Fertilisers, Phosphate of Ammonia and Superphosphate ; also of Sulphate of Ammonia and Urea.

Long Hoos, 1927.

N.E.

I	3	1	5	2	4
II	5	4	2	3	1
III	4	5	3	1	2
IV	1	2	4	5	3
V	2	3	1	4	5

SYSTEM OF REPLICATION : Latin Square. Plots, $\frac{1}{25}$ acre. Supplying 75 lbs. P_2O_5 and 14.75 lbs. N. per acre.

1. Urea equivalent to 2.
2. Sulphate of Ammonia at the rate of $\frac{5}{8}$ cwt. per acre.
3. Ammonium Phosphate at the rate of 1.1 cwts. per acre.
4. Urea as 1+Superphosphate at the rate of 4 cwts. per acre.
5. Sulphate of Ammonia as 2+Superphosphate at the rate of 4 cwts. per acre.

All plots received 1 cwt. Muriate of Potash per acre.
Manures applied June 20.
Seed sown June 23 ; roots lifted November 25 and 30.

Actual Weights in lb.

Row.	Roots.					Tops.				
	1	2	3	4	5	1	2	3	4	5
I	1236	1488	1196	1428	1280	473.0	497.0	465.5	437.5	498.5
II	1448	1296	1472	1248	1252	428.0	454.0	484.0	478.5	523.0
III	1468	1408	1328	1264	1264	467.0	425.5	482.5	519.0	473.0
IV	1236	1308	1456	1324	1416	481.5	503.0	414.0	478.0	437.0
V	1252	1168	1352	1472	1504	444.5	481.5	495.5	431.0	434.0

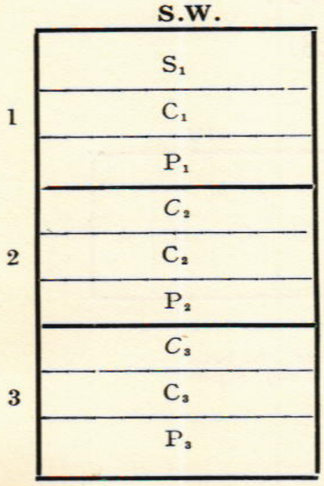
Summary of Results.

Average Yield per acre.	No Phosphate.		Phosphate applied.			Mean.	Standard Error.
	Urea.	Sulphate.	Amm'nium Phosphate.	Urea and Super.	Sulphate and Super.		
Roots, tons ...	14.82	14.88	15.19	15.04	14.99	14.98	0.22
Roots, per cent.	98.9	99.3	101.4	100.4	100.1	100.0	1.45
Tops, tons ...	5.12	5.27	5.23	5.23	5.28	5.23	0.12
Tops, per cent.	98.0	100.9	100.0	100.1	101.0	100.0	2.32

The yields on the Phosphate plots appear to be greater than those on the no-Phosphate plots, but the difference is not significant.

CULTIVATION EXPERIMENT.

Rotary cultivation : method of making a seed bed.
Barley, Sawyers Field, 1927.



System of Replication : Triplicate strips. Plots $\frac{1}{40}$ acre.

S = prepared by Simar rototiller, April 14, 1927.

C_2, C_3 = as S in 1926, but treated as C in 1927.

C = Horse cultivated and disc harrowed, May 2.

P = Ploughed, April 5 and 14 ; drag harrowed and rolled, May 6, 1927.

All plots previously ploughed in January, 1927. 3 cwt. Superphosphate, 1 cwt. Muriate of Potash and 1 cwt. Sulphate of Ammonia per acre, applied over whole area, April 19, 1927.

Barley sown, May 7. Harvested October 3–12.

Actual Weights in lb.

Grain.	S *and* C	C	P
1	409.75	282.875	284.125
2	400.5	301.125	345.75
3	383.75	344.75	308.875
Total ...	1194.0	928.75	938.75
Straw.	S *and* C	C	P
1	602.0	473.5	439.0
2	698.5	641.5	621.5
3	702.0	601.5	627.0
Total ...	2002.5	1716.5	1687.5

Summary of Results.

	S *and* C	C	P	Mean.	Standard Error.
Grain, cwts. per acre	12.9	10.1	10.2	11.0	0.54
Grain, per cent.	117.0	91.0	92.0	100.0	4.89
Straw, cwts. per acre	21.7	18.6	18.3	19.5	0.46
Straw, per cent.	111.1	95.3	93.6	100.0	2.35

Plots cultivated with the Simar implement in 1926 show a significant superiority over others in both grain and straw in 1927. This was probably a residual effect from previous years, as only one of these plots was in 1927 treated differently from the horse cultivated plots.

CULTIVATION EXPERIMENT.

Swedes, Great Harpenden, 1928.

S

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

SYSTEM OF REPLICATION: 4 randomised blocks of 4 plots each.
Area of each plot: $\frac{1}{80}$ acre.
No Farmyard Manure, except that plots marked * were dunged in error. All plots had 2 cwt. Sulphate of Ammonia, 2 cwt. Muriate of Potash and 2 cwt. Superphosphate per acre, applied May 5.

A = Ridged Seed bed.
B = Prepared by Simar rototiller, then ridged.
C = Prepared by Simar rototiller, but left flat.
D = Prepared by Simar rototiller, left flat, and Simar implement used again between rows in July.
Special cultivations May 7-9. Seed sown, May 9. Roots lifted November 21-25.

Actual Yields.

Block.	Roots in lb.				Tops in lb.				Number of Roots.			
	A	B	C	D	A	B	C	D	A	B	C	D
I	2804	2886	2529.5	2064	124	126.5	98.5	90	1018	991	903	815
II	2392	2417	2062	1967.5	100	107	85.5	87.5	1011	1022	784	773
III	2395	2437	2039	2046.5	89	103.5	76	90.5	929	899	832	730
IV	2566	2472.5	2381.5	1996	158	131.5	122.5	91.5	954	966	805	776

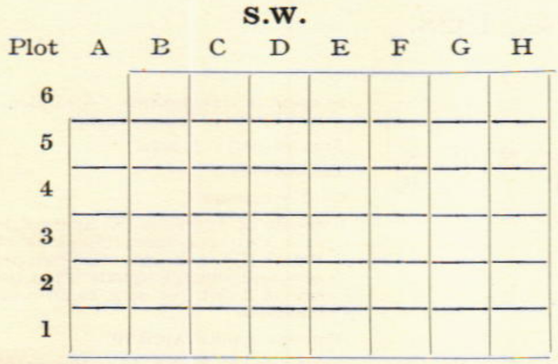
Summary of Results.

Average Yield.	Ridged.	Simar and Ridged.	Simar and Flat.	Simar, flat and Simar.	Mean.	Standard Error.
Roots, tons per acre ...	22.67	22.80	20.12	18.02	20.90	0.50
Roots, per cent. ...	108.5	109.1	96.2	86.2	100.0	2.39
Tops, cwt. per acre ...	21.03	20.92	17.08	16.05	18.77	1.13
Tops, per cent. ...	112.0	111.4	91.0	85.5	100.0	6.03
Roots, number per acre	19560	19390	16620	15470	17760	338.8
Roots, number per cent.	110.1	109.2	93.6	87.1	100.0	1.91

Significant depression in both roots and tops in the case of the plots simared and left flat. A further significant depression with roots in the case of the doubly simared plots. These depressions are accounted for by the decreased numbers of plants.

UNIFORMITY TRIAL.

Oats, Sawyers Field, 1927.



Area of each plot : $\frac{1}{10}$ acre.

Area was dunged in 1926 for Swedes. No other manure.

Sown February 18-19. Harvested August 22, 23, 30.

Actual Weights in lb.

Plot.	A	B	C	D	E	F	G	H	Total.
Total Grain.									
6		274.5	265.375	289.0	282.125	290.375	271.0	261.5	1933.875
5	252.0	263.25	255.375	230.75	313.625	276.625	234.625	258.875	2085.125
4	229.25	249.875	250.375	242.0	310.500	280.625	255.25	229.125	2047.000
3	229.25	251.625	265.75	259.375	262.000	257.000	235.625	268.875	2029.500
2	207.25	244.625	238.0	231.375	215.250	262.875	237.25	225.25	1861.875
1	187.375	212.125	223.75	220.25	210.875	232.125	229.875	242.25	1758.625
Total	1105.125	1496.000	1498.625	1472.750	1594.375	1599.625	1463.625	1485.875	11716.000
Total Straw.									
6		259.5	234.0	272.0	259.0	288.0	255.0	282.5	1850.0
5	252.5	266.0	236.5	236.5	300.0	270.5	277.5	287.5	2127.0
4	241.5	256.0	237.0	237.5	256.5	284.0	250.5	259.5	2022.5
3	256.0	267.5	260.5	252.0	246.0	259.5	252.5	274.0	2068.0
2	248.5	273.0	238.0	228.0	218.0	269.5	257.0	261.0	1993.0
1	225.0	241.0	222.5	235.0	211.0	249.5	242.0	273.0	1899.0
Total	1223.5	1563.0	1428.5	1461.0	1490.5	1621.0	1534.5	1637.5	11959.5

Summary of Results.

	Grain.		Straw.	
	lb.	cwts.	lb.	cwts.
Average Yield per acre	2493	22.3	2545	22.7
Standard deviation	263.9	2.36	195.7	1.75
Standard deviation per cent. ...	10.6		7.7	

https://doi.org/10.23637/ERADOC-1-85

WOBURN.

Barley : Effect of fertilisers on yield and quality.

Butt Close, 1928.

S.

A								B							
N	NK	NP	O	NKP	K	KP	P	O	NKP	KP	K	NP	N	P	NK

C								D							
NK	O	N	NKP	P	NP	KP	K	O	K	NP	NKP	NK	P	KP	N

System of Replication : 4 randomised blocks of 8 plots each.

Area of plot : $\frac{1}{40}$ acre.

Treatments :

O=No manure.

Sulphate of Ammonia (N) at the rate of 1 cwt. per acre ; Sulphate of Potash (K) at the rate of $1\frac{1}{2}$ cwt. per acre, and Superphosphate (P) at the rate of 3 cwt. per acre, in all combinations.

Manures applied April 19.

Barley sown, March 17 ; Harvested August 9.

Variety: "Spratt Archer."

Actual Weights in lb.—Total Grain.

Block.	O	P	N	K	NP	KP	NK	NKP
A	43.25	37.25	61.25	78.75	55.5	43.25	67.25	31.25
B	34.0	61.25	48.0	57.0	38.75	66.0	64.0	57.25
C	42.0	41.5	47.0	55.75	43.75	44.0	45.25	42.5
D	23.25	52.25	77.75	53.75	60.5	59.75	46.5	53.25

Actual Weights in lb.—Total Straw.

Block.	O	P	N	K	NP	KP	NK	NKP
A	59.75	54.0	86.0	93.25	80.75	56.0	94.5	44.75
B	45.75	62.0	55.75	60.75	54.5	79.5	81.0	71.0
C	67.0	52.75	75.5	73.75	70.75	59.0	77.75	65.0
D	40.25	55.5	80.0	68.5	86.0	63.75	54.0	68.5

Summary of Results.

Average Yield.	No Manure.	Super.	S/Amm.	S/Potash	S/Amm. + Super.	S/Potash + Super.	S/Am. + S/Potash	S/Am. + S/Potash + Super.	Mean.	Standard Error.
Grain, cwts. per acre ...	12.7	17.2	20.9	21.9	17.7	19.0	19.9	16.5	18.2	2.05
Grain, per cent.	69.8	94.2	114.7	120.2	97.3	104.4	109.3	90.3	100.0	11.26
Straw, cwts. per acre ...	19.0	20.0	26.5	26.5	26.1	23.1	27.4	22.3	23.9	2.31
Straw, per cent.	79.6	83.9	111.3	110.9	109.3	96.7	115.0	93.3	100.0	9.69
Per cent. Nitrogen in dry matter of grain	1.316	1.296	1.340	1.387	1.398	1.328	1.346	1.372	1.348	0.036

Significant interaction of the nitrogenous and potassic fertilisers. In the absence of one the other increased the yield significantly, but in the presence of one there was no effect due to the adding of the other. With straw there was a direct significant response to Sulphate of Ammonia.

WOBURN.

Potatoes : Nitrogenous Fertilisers, Sulphate of Ammonia and Cyanamide, each in single and double dressings.

Lansome, 1926.

I	2C	1S	1C	0	2S
II	1S	1C	2C	2S	0
III	2S	2C	0	1C	1S
IV	0	2S	1S	2C	1C
V	1C	0	2S	1S	2C

Variety : King Edward.

System of Replication : Latin Square.

Area of each plot 28 ft. × 31 ft. = $\frac{1}{50}$ acre.

Treatments :

0 : Control.

1S : 1 cwt. Sulphate of Ammonia per acre.

2S : 2 cwt. Sulphate of Ammonia per acre.

1C : Single Cyanamide = 1 cwt. S/Amm.

2C : Double Cyanamide = 2 cwt. S/Amm.

All plots had a basal dressing of Farmyard Manure, Sulphate of Potash and Superphosphate, applied with S/Amm. in the bouts on May 10 ; 2C applied April 23 ; 1C on April 30. Dung carted and spread May 3-8.

Potatoes planted May 10-12 ; lifted October 11-12.

Actual Yields in lb.

Rows.	0	1C	1S	2C	2S
I	293	368	370	380	387
II	322	331	320	354	334
III	268	332	321	359	370
IV	292	298	322	347	347
V	282	298	321	295	322

Summary of Results.

Average Yield.	No Nitrogen.	Single Cyanamide	Single Sulphate.	Double Cyanamide	Double Sulphate.	Mean.	Standard Error.
Tons per acre	6.50	7.26	7.38	7.75	7.86	7.35	0.20
Per cent. ...	88.5	98.8	100.4	105.4	106.9	100.0	2.71

Significant response to nitrogen in both single and double dressings. The difference between Sulphate and Cyanamide is insignificant.

WOBURN.

Potatoes : Effect of Superphosphate.

1927. Butt Close.
Variety: Arran Comrade.

S.

I	9	3	6	0
II	6	9	0	3
III	0	6	3	9
IV	3	0	9	6

1928. Stackyard.
Variety {Row I, Ally. Rows II, III and IV, Majestic.

N.W.

I	6	3	0	9
II	9	0	6	3
III	3	6	9	0
IV	0	9	3	6

System of Replication : 4×4 Latin Square. Area of each plot $\frac{1}{40}$ acre.
Treatments : Superphosphate at the rate of 0, 3, 6 and 9 cwts. per acre.
Basal Dressings—1927 : 10 tons F.Y.M. per acre.
1928 : 14 tons F.Y.M., 1½ cwts. Sulphate of Ammonia and 1½ cwts. Muriate of Potash per acre.
Artificial Manures applied {1927 : June 15-16. 1928 : May 5-9.
Potatoes planted {1927 : June 25. 1928 : May 5-9.
Potatoes lifted {1927 : October 27-28. 1928 : October 24-26.

Actual Weights in lb.

Row.	1927				1928			
	0	3	6	9	0	3	6	9
I	234	231	257	245	713	716	691	779
II	259	244	208	239	708	776	894	837
III	217	245	221	205	743	712	773	867
IV	198	198	200	224	580	804	778	807

Summary of Results.

Year.	Average Yield.	Basal.	Basal +3 cwt. Super.	Basal +6 cwt. Super.	Basal +9 cwt. Super.	Mean.	Standard Error.
1927	Tons per acre	4.06	4.10	3.96	4.08	4.04	0.11
	Per cent. ...	100.2	101.3	97.8	100.7	100.0	2.62
1928	Tons per acre	12.25	13.43	14.00	14.69	13.59	0.27
	Per cent. ...	90.1	98.8	103.0	108.1	100.0	2.00

1927 : No response to Superphosphate on very low yields.
1928 : Significant response to Superphosphate.

https://doi.org/10.23637/ERADOC-1-85

WOBURN.

Potatoes : Nitrogenous Fertilisers, Sulphate of Ammonia, Urea, Cyanamide, each in single and double dressings.

Lansome, 1927.

N.W.

A			B		
0(a)	1U	2S	0(a)	0(b)	2C
2U	1C	1S	0(c)	2U	2S
2C	0(b)	0(c)	1C	1S	1U
1S	2S	1U	2U	2C	0(a)
2U	2C	0(a)	1U	1C	1S
1C	0(b)	0(c)	2S	0(b)	0(c)
C			D		

VARIETY : King Edward.

SYSTEM OF REPLICATION : 4 randomised blocks.

Area of Plots : $\frac{1}{40}$ acre.

0 = Control.

1–2 = Nitrogen at the rate of 1½ and 3 cwts. per acre, Sulphate of Ammonia or its equivalent, applied May 19-20.

S = Sulphate of Ammonia.

C = Cyanamide.

U = Urea.

All plots had basal dressing of 3 cwt. Super and 2 cwt. Mur/Pot. per acre applied May 19-20 ; also 10 tons dung per acre, applied May 9-13.

Potatoes planted May 23 ; lifted October 12-18.

Actual Yields in lb.

Block.	0(a)	0(b)	0(c)	1U	1C	1S	2U	2C	2S
A	410	432	411	436	426	399	407	424	362
B	361	361	369	374	376	436	382	352	332
C	372	361	338	399	380	456	381	371	418
D	355	327	289	376	362	315	383	361	329

Summary of Results.

Average Yield.	O	Single Urea.	Single Cyanamide	Single Sulphate.	Double Urea.	Double Cyanamide	Double Sulphate.	Mean.	Standard Error.
Tons per acre	6.53	7.08	6.89	7.17	6.93	6.73	6.43	6.76	0.249
Per cent. ...	96.6	104.7	102.0	106.1	102.6	99.6	95.2	100.0	3.69

Significant response to single dressing of Nitrogen. The double dressing of Urea and Cyanamide produced no further increase, while that of Sulphate of Ammonia reduced the yield.

WOBURN.

Potatoes : Nitrogenous Fertilisers, Sulphate of Ammonia, Cyanamide (each with and without nitrate of soda), Nitrophoska, Compound " B."

Stackyard, 1928.

N.W.

A

15	16	2	13	9	10	1	17	5	12	4	8	3	6	14	11	18	7

B

17	3	14	13	18	11	6	15	2	1	10	12	7	8	5	9	4	6

C

6	10	3	2	18	7	12	9	1	5	15	4	11	8	13	17	16	14

D

17	3	14	1	6	16	15	5	12	9	4	2	7	8	13	11	18	10

VARIETY : Majestic. Block A sown with " Ally."
SYSTEM OF REPLICATION : 4 randomised blocks of 18 plots each.
AREA OF PLOT : $\frac{1}{40}$ acre.
TREATMENTS : Compound Fertiliser " B " and Nitrophoska equivalent to $1\frac{1}{2}$ cwt. per acre Sulphate of Ammonia ; Sulphate of Ammonia and Cyanamide with and without Nitrate of Soda at the rate of $1\frac{1}{2}$ cwt. S/Amm. or equivalent, together with Sulphate of Potash and Superphosphate* to raise to equivalence with compound fertilisers.

KEY TO TREATMENTS.

NITROGEN = $1\frac{1}{2}$ cwt. S/Amm. Others in cwt. per acre

Treatment.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Nitrogen	"B"	Nitro-phoska.		Cyana-mide.		$\frac{2}{3}$ Cyanam. $\frac{1}{3}$ Nit/Soda		Sulphate of Amm.		$\frac{2}{3}$ S/Amm. $\frac{1}{3}$ Nit/Soda		"B"	Nitro-phoska.		No Nitrogen.			
Potash ...	–	–	$\frac{1}{4}$	2	$1\frac{3}{4}$	2	$1\frac{3}{4}$	2	$1\frac{3}{4}$	2	$1\frac{3}{4}$	–	–	$\frac{1}{4}$	2	2	$1\frac{3}{4}$	$1\frac{3}{4}$
Phosphate	–	–	$\frac{1}{4}$	1	$\frac{3}{4}$	1	$\frac{3}{4}$	1	$\frac{3}{4}$	1	$\frac{3}{4}$	–	–	$\frac{1}{4}$	1	1	$\frac{3}{4}$	$\frac{3}{4}$
Calcium Sulphate												=2P	$=1\frac{3}{4}$P	=2P				

Plots 12 to 14 had Calcium Sulphate added equivalent to that in 2 and $1\frac{3}{4}$ cwt. Superphosphate as shown.
* Plots 16 and 18 had Phosphate in the form of Potassium Phosphate equivalent to that in Superphosphate.
All plots had 14 tons F.Y.M. per acre. Artificial manures applied May 5-9.
Potatoes planted May 5-9 ; lifted October 24-26.

Actual Weights in lb.

Block.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
A	782	724	754	654	743	773	744	845	744	805	766	783	762	702	610	688	634	531
B	850	827	812	645	686	754	769	804	804	757	836	860	821	771	704	565	663	759
C	840	874	834	793	779	697	807	830	757	833	809	808	695	688	685	648	771	775
D	755	783	744	687	706	761	779	771	762	676	694	771	647	731	714	699	624	576
Average, tons per acre	14.4	14.3	14.0	12.4	13.0	13.3	13.8	14.5	13.7	13.7	13.9	14.4	13.1	12.9	12.1	11.6	12.0	11.8

Summary of Significant Results.

					With Potash and Phosphate equivalent to compound fertilisers.					
Average Yield.	No Nitrogen.	Nitro-phoska.	Standard Error(*a*).	Comp'nd "B."	Sulphate of Amm.	S/Am.+ Nit/Soda.	Cyana-mide.	Cyana.+ Nit/Soda.	Mean.	Standard Error(*b*).
Tons per acre	11.88	13.58	0.24	14.40	14.10	13.79	12.71	13.58	13.28	0.33
Per cent.	89.5	102.3	1.77	108.4	106.2	103.4	95.7	102.3	100.0	2.51

(*a*) Refers to means of 16 plots.
(*b*) Refers to means of 8 plots.

Significant response to Nitrogen except where Cyanamide was the only Nitrogenous Manure applied. No significant differences between the other nitrogenous fertilisers, or between the plots receiving Phosphate as a Calcium Salt and in other forms.

https://doi.org/10.23637/ERADOC-1-85

WOBURN.

Sugar Beet : (a) Comparison of Nitrogenous Fertilisers : Sulphate and Muriate of Ammonia and Cyanamide.

(b) Preparation of Seed Bed.

Butt Close, 1927.

S.S.W.

R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F	R	F
2S	0C	0S	1S	1M	2C	0C	1S	1M	2C	2S	0M	2C	1S	0S	2M	1M	0M
0C	1C	1S	2M	2C	0M	1S	2M	2C	0S	0M	1C	1S	0C	2M	1C	0M	2S
1C	2S	2M	0S	0M	1M	2M	0C	0S	1M	1C	2S	0C	2C	1C	0S	2S	1M
		A						B						C			

QUANTITIES : Nitrogen at the rate of 0, 1, 2 cwt. per acre Sulphate of Ammonia or equivalent.

S = Sulphate of Ammonia.
M = Muriate of Ammonia.
C = Cyanamide.
R, F = Alternative Strips with ridged and flat seed bed.

SYSTEM OF REPLICATION : 3 randomised blocks of 18 plots each.

AREA OF EACH PLOT : $\frac{1}{40}$ acre.
Seed sown June 16. Pulled Jan. 5-13, 1928.

All plots received 3 cwt. Super. and 2 cwt. Muriate of Potash per acre, applied with other manures June 10-14. Dung applied February 22-24 (14 loads per acre). Ground chalk April 6 (1 ton per acre).

Actual weights in lb.

Blocks.		0C	0S	0M	1C	1S	1M	2C	2S	2M
ROOTS.										
A	R	100.5	67.5	90.0	95.0	79.0	79.0	114.5	125.0	95.5
	F	100.5	114.5	119.5	127.0	91.0	145.5	99.5	123.5	133.0
B	R	68.0	95.0	101.0	129.5	104.0	92.0	114.0	109.0	124.5
	F	101.5	147.0	148.5	163.5	102.0	143.5	154.5	156.0	126.5
C	R	126.5	135.5	162.0	150.5	131.5	134.5	136.0	171.0	184.0
	F	166.0	121.5	129.5	184.5	186.0	157.0	155.5	192.5	191.0
TOPS.										
A	R	185.0	117.0	164.0	170.0	125.0	131.0	216.0	241.0	192.0
	F	195.0	226.0	218.0	243.0	167.0	286.0	176.0	236.0	276.0
B	R	115.0	131.0	163.0	199.5	157.0	140.0	163.0	175.5	206.0
	F	132.0	229.0	245.0	294.0	179.0	228.0	299.5	262.0	216.0
C	R	181.0	238.0	274.0	211.0	243.0	217.0	234.0	255.0	262.0
	F	250.0	196.0	251.0	270.0	295.5	255.0	250.0	350.0	305.0

(1) Summary of Results, Manuring Experiment.

ROOTS.

Quantity of Nitrogen.	Average Yield in Tons per acre.			Average Yield per cent.		
	Cyanamide.	Sulphate.	Muriate.	Cyanamide.	Sulphate.	Muriate.
0		2.60			91.1	
1	3.16	2.58	2.80	110.9	90.5	98.1
2	2.88	3.26	3.18	101.0	114.5	111.5
Standard Error	0.16			5.60		

TOPS.

Quantity of Nitrogen.	Average Yield in tons per acre.			Average Yield per cent.		
	Cyanamide.	Sulphate.	Muriate.	Cyanamide.	Sulphate.	Muriate.
0		4.35			90.5	
1	5.16	4.34	4.68	107.3	90.2	97.2
2	4.98	5.65	5.42	103.5	117.5	112.7
Standard Error	0.34			7.02		

(2) Summary of Results, Cultivation Experiment.

Average Yield.	Ridged.	Flat.	Mean.	Standard Error.
Roots, tons per acre	2.57	3.13	2.85	0.08
Roots, per cent. ...	90.3	109.7	100.0	2.77
Tops, tons per acre	4.22	5.40	4.81	0.17
Tops, per cent. ...	87.8	112.2	100.0	3.44

Well marked superiority of flat over ridged seed bed. Significant response to both single and double Nitrogen except in the case of the Sulphate plots (single dressing), while with Cyanamide there was a depression in yield with the higher dressing.

https://doi.org/10.23637/ERADOC-1-85

WOBURN.

SUGAR BEET.

Nitrogenous Fertilisers : Sulphate of Ammonia } Each applied
Muriate of Ammonia } with seed.
Nitrochalk as top dressing.

Potassic Fertilisers : Muriate of Potash.
Potash Manure Salts.

Nitrophoska.

Butt Furlong, 1928.

S.

A	12	9	2	4	13	5	3	8	7	1	6	10	11
B	6	7	12	4	13	1	3	10	5	2	8	9	11
C	6	2	12	3	4	8	7	11	1	10	5	9	13
D	9	4	12	2	13	5	11	10	6	7	3	8	1
E	12	5	10	3	13	7	8	6	1	2	4	9	11
F	1	8	2	6	9	12	10	5	4	13	11	7	3

VARIETY : Dippe.

SYSTEM OF REPLICATION : 6 randomised blocks of 13 plots each.

Area of each plot : $\frac{1}{40}$ acre.

TREATMENTS : Sulphate and Muriate of Ammonia alone at the rate of 1½ cwt. S/Amm. per acre or equivalent, also at half this rate combined with equivalent Nitrochalk as Top Dressing. Muriate of Potash and Potash Manure Salts at the rate of 1 cwt. per acre M/Pot. or equivalent. Superphosphate at the rate of 1½ cwt. per acre. Nitrophoska equivalent to 1½ cwt. S/Amm. Basal Manure : 12 tons F.Y.M. per acre March 30–April 4. Artificial Manures applied May 22-23, except top dressing, which was applied July 5.

Seed sown, May 18 ; Roots lifted November 8-13.

Key to Treatments.

	Manure.	1	2	3	4	5	6	7	8	9	10	11	12	13
Nitrogen = 1½ cwt. S/Am.	S/Amm. ...	×		×		×		×		×		×		
	M/Amm. ...		×		×		×		×		×		×	
	Nitro-chalk			×	×			×	×			×	×	
Potash = 1 cwt. M/Pot.	M/Pot. ...	×	×	×	×									
	P.M.S. ...					×	×	×	×					
Super at 1½ cwt.		×	×	×	×	×	×	×	×	×	×	×	×	
Nitrophoska ...														×

Actual Weights in lb.—Roots.

Block.	1	2	3	4	5	6	7	8	9	10	11	12	13
A	799	861	799	885	785	760	812	820	930	761	789	901	901
B	735	763	649	861	654	881	890	729	726	623	726	881	864
C	772	912	828	861	784	830	811	841	701	735	737	895	757
D	689	911	746	873	880	803	759	752	817	802	872	890	902
E	739	713	957	720	869	717	871	881	708	879	730	911	952
F	806	891	699	764	738	881	663	924	800	815	781	833	764

Actual Weights in lb.—Tops.

Block.	1	2	3	4	5	6	7	8	9	10	11	12	13
A	706	879	640	840	630	669	820	741	803	679	629	799	848
B	638	535	398	734	421	651	680	521	476	419	570	741	698
C	602	747	937	931	631	859	733	992	565	557	594	883	678
D	552	850	615	710	875	582	631	643	711	610	792	810	859
E	647	667	733	682	622	651	863	863	672	647	683	655	786
F	546	563	729	768	755	736	716	591	710	778	829	797	812

(1) Summary of Average Yields, Separate Treatments.

	Yield in tons per acre.	Sulphate of Ammonia.		Muriate of Ammonia.		Nitro-phoska.
		Top Dressing.	No Top Dressing.	Top Dressing.	No Top Dressing.	
Roots	Muriate of Potash	13.92	13.51	14.77	15.03	15.30
	Potash Manure Salts	14.30	14.02	14.72	14.50	
	No Potash ...	13.79	13.93	15.81	13.74	
Tops	Muriate of Potash...	12.06	10.99	13.88	12.62	13.93
	Potash Manure Salts	13.22	11.71	12.95	12.35	
	No Potash ...	12.19	11.72	13.94	10.98	
Sugar percentage in roots	Muriate of Potash...	18.37	17.80	17.85	17.68	17.63
	Potash Manure Salts	17.60	18.43	17.72	17.98	
	No Potash ...	18.70	17.97	17.72	18.33	

(2) Summary of Significant Results.

Average Yield.	Sulphate Amm.	Muriate Amm.	Sulphate+ Nitrochalk.	Muriate+ Nitrochalk.	Standard Error (*a*).	Nitro-phoska.	Standard Error (*b*).	Mean.
†Roots, tons per acre	13.82	14.42	14.00	15.10	0.32	15.30	0.55	14.41
Roots, per cent. ...	95.9	100.1	97.2	104.8	2.20	106.2	3.80	100.0
Tops, tons per acre	11.47	11.98	12.49	13.59	0.45	13.93	0.77	12.50
Tops, per cent. ...	91.8	95.8	99.9	108.7	3.56	111.4	6.17	100.0
*Sugar percentage ...	18.07	18.00	18.22	17.76	0.18*	17.63	0.31*	17.96

(*a*) Refers to means of 18 plots. (*b*) Refers to means of 6 plots.
* From 45 plots only.
† Roots weighed dirty. Approximately 20% should be subtracted for tare.

Muriate of Ammonia beats Sulphate of Ammonia significantly, while the response to top dressing is significant only in the case of tops. Nitrophoska plots appear to be better than the plots receiving all Nitrogen as basal. No significant differences in sugar content and no response to potash.

WOBURN: OTHER EXPERIMENTS.

Mangolds and Potatoes: Nitrogenous Fertilisers, Sulphate of Ammonia and Muriate of Ammonia (one half at sowing, one half as top dressing), Muriate of Potash.

Mangolds, Warren Field. Potatoes, Lansome Field, 1926.

All plots received 9 tons F.Y.M. and 2 cwt. superphosphate per acre. Plots 1, 2 and 3 had in addition a basal dressing of 1 cwt. Sulphate of Potash, while Plots 4 and 5 had 2 cwt. Sulphate of Ammonia (one half at sowing, one half as top dressing). Area of each plot ¼ acre.

Plot Number	1	2	3	4	5
Additional Manuring per acre.	Muriate of Amm. equiv. to 2 cwt. S/Amm. ½ sowing, ½ top dressing.	No Nitrogen.	2 cwt. Sulphate of Ammonia, ½ sowing, ½ top dressing	No Potash.	Muriate of Potash equiv. to 1 cwt. Sulphate of Potash
Produce in tons per acre: Mangolds	23.28	17.96	21.8	23.49	23.91
Produce in tons per acre: Potatoes	6.19	5.38	6.07	5.61	6.30

Mangolds: Top Dressings, Sulphate of Ammonia, Nitrate of Soda, Salt.

Road Piece, 1927.

Area of each plot ¼ acre. Basal dressing: 3 cwt. superphosphate, 2 cwt. Kainit and 1 cwt. Sulphate of Ammonia per acre.

Plot Number.	1	2	3	4	5	6
Manuring: per acre.	No Top Dressing.	1 cwt. Sulphate of Ammonia.	Nitrate of Soda equiv. to S/Am.	1 cwt. S/Amm. 3 cwt. Salt.	Nitrate of Soda equiv. to S/Am. 3 cwt. Salt.	3 cwt. Salt.
Produce of Roots in tons per acre	14.24	16.91	18.20	19.79	20.05	20.51

LUCERNE, INOCULATION OF.

Mill Dam Close, 1928.

Yield of Lucerne Hay per plot (.15 acre).

Inoculated.

Plot Number.	1	3	5	7	9	11	Total.	Average per acre, cwt.
Yield in lb.	714	658	602	553	644	602	3773	37.4

Not Inoculated.

Plot Number.	2	4	6	8	10	—	Total.	Average per acre, cwt.
Yield in lb.	532	658	504	420	476	—	2590	30.8

Difference in favour of the Inoculated Plots = 6.6 cwts. per acre.
Standard Error of this Difference = 2.6 cwts.
The yield of hay from the Inoculated Plots is significantly greater than that from the not-Inoculated Plots.

REPLICATED EXPERIMENTS AT OUTSIDE CENTRES.

Grassland. New Hay. Effect of Basic Slag.

(Basic Slag Committee.)

Mr. B. W. H. Pratt, Brooke, Norfolk, 1926-1928.

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 lbs. P_2O_5 per acre in March, 1926.
No manures in 1927 or 1928.

Actual Weights in lb.

	1926				1927				1928			
Row.	C	L	M	H	C	L	M	H	C	L	M	H
I	1194	1187	1367	1583	499	649	963	871	336	621	584	722
II	1154	1230	1227	1224	449	606	735	780	389	420	537	813
III	1317	1439	1086	1523	554	752	809	904	513	522	677	599
IV	1450	1241	1488	1595	607	790	841	999	430	560	680	720

Summary of Results.

Year.	Average Yield in cwts. per acre.						Per Cent.					
	Control.	Low Soluble.	Medium Soluble.	High Soluble.	Mean.	Standard Error.	Control.	Low Soluble.	Medium Soluble.	High Soluble.	Mean.	Standard Error.
1926	45.7	45.5	46.1	52.9	47.6	2.56	96.0	95.7	97.0	111.2	100.0	5.38
1927	18.8	25.0	29.9	31.7	26.4	1.06	71.4	94.7	113.4	120.4	100.0	4.01
1928	14.9	19.0	22.1	25.5	20.4	0.92	73.1	93.1	108.6	125.1	100.0	4.52
Total	79.4	89.5	98.1	110.1	94.4	—	—	—	—	—	—	—

1926. Significant response to high soluble slag only.
1927. Significant progressive increases up to medium soluble slag. The high soluble produced no further increase.
1928. Significant response to all grades of slag, which range themselves in order of citric solubility.
1926-28. Large seasonal falling off in yield. Effect on yield is least with the low soluble slag and greatest with the high soluble.

https://doi.org/10.23637/ERADOC-1-85

Grassland. Old Hay. Effect of Basic Slag.

(Basic Slag Committee.)

Mr. E. Habberfield, Home Farm, Enmore, Somerset, 1926-1928.

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: $\frac{1}{4}$ 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%).

Slags applied at the rate of 100 lbs. P_2O_5 per acre in March, 1926.

Actual Weights in lb.

	1926				1927				1928			
Rows.	C	L	M	H	C	L	M	H	C	L	M	H
I	783	791	942	1149	837	685	906	995	223	244	321	377
II	804	1027	905	875	733	921	983	742	312	412	468	270
III	807	708	959	852	768	767	879	1046	308	304	416	355
IV	667	823	747	556	590	945	870	827	213	295	356	323

Summary of Results.

Year.	Average Yield per acre.						Per Cent.					
	Control.	Low Soluble.	Medium Soluble	High Soluble.	Mean.	Stand'rd Error.	Control.	Low Soluble.	Medium Soluble.	High Soluble.	Mean.	Stand'rd Error.
1926	27.3	29.9	31.7	30.6	29.9	2.15	91.4	100.0	106.1	102.5	100.0	7.20
1927	26.1	29.6	32.5	32.2	30.1	1.08	86.8	98.4	107.8	107.0	100.0	3.60
1928	9.4	11.2	13.9	11.8	11.6	0.86	81.3	96.6	120.1	102.0	100.0	7.38
Total	62.8	70.7	78.1	74.6	71.6	—	—	—	—	—	—	—

1926. No significant response to treatment.

1927. Significant progressive increase up to medium soluble slag. The high soluble produced no further increase in yield.

1928. Medium soluble slag gave significantly greater yield than the others, while all grades of slag did significantly better than Control.

1926-28. Poor yield in 1928. All grades of slag have improved the yield, but medium soluble slag has done rather better than high soluble.

https://doi.org/10.23637/ERADOC-1-85

Basic Slag on Arable Land.

(Basic Slag Committee.)

Mr. Hyatt, Andoversford, Glos., 1926-27.

1926 : Swedes (fed off on land). Sown June 2.
1927 : Oats (carted and weighed green). Harvested September 6.

I	C	S	H	M	L
II	L	C	S	H	M
III	S	H	M	L	C
IV	M	L	C	S	H
V	H	M	L	C	S

Soil : Loam on limestone (Lower Oölite).
System of Replication : Latin Square.
Area of each plot : $\frac{1}{25}$ acre.
Treatments :
C = Control.
L = Low soluble slag (37.3%).
M = Medium soluble slag (60.9%).
H = High soluble slag (86.8%).
S = Superphosphate.
Rate : 100 lbs. $P_2 O_5$ per acre, applied May, 1926.
Basal Manuring : F.Y.M. 12 loads per acre, 1 cwt. Sulphate of Ammonia and 1 cwt. Muriate of Potash per acre for Swedes in 1926. No further Manure applied in 1927.

Actual Weights in lb.

Row.	1926 C	1926 L	1926 M	1926 H	1926 S	1927* C	1927* L	1927* M	1927* H	1927* S
I	724	923	1031	1067	1132	262	245	266	276	283
II	824	915	1037	1053	1123	300	295	284	311	303
III	745	881	977	886	1024	257	258	265	252	242
IV	683	722	879	947	1025	258	237	252	302	246
V	757	877	904	1035	929	262	290	256	264	267

Summary of Results.

	Average Yield.	Control.	Low Soluble.	Med. Soluble.	High Soluble.	Super-ph'sph'te	General Mean.	Standard Error.
1926	Per acre, tons ...	8.33	9.64	10.78	11.13	11.68	10.31	0.26
	Per cent. ...	80.8	93.5	104.5	108.0	113.3	100.0	2.53
1927	Grain, per acre, bush.	40.8	40.4	36.0	45.3	36.9	39.8	1.08
	Grain, per cent.	102.3	101.3	90.2	113.6	92.5	100.0	2.70*
	Straw, per acre, cwt.	15.8	15.2	14.9	17.5	14.8	15.7	0.42
	Straw, per cent. ...	101.1	97.2	95.1	111.8	94.7	100.0	2.70*

* The oats were carted and weighed green, but later samples were dried and threshed. From these the above yields of grain and straw were calculated, but the analysis of variance was performed on the original totals and the standard error thus obtained is appended as above to both grain and straw.

1926. Significant response to all grades of slag. Superphosphate plots did significantly better than medium and low soluble plots.
1927. Significant response to high soluble slag only.

https://doi.org/10.23637/ERADOC-1-85

Basic Slag on Arable Land.

(Basic Slag Committee.)

Mr. Reeves, Matley Hyde, Stalybridge, Cheshire, 1926-28.

1926 : Swedes (carted off). Roots and leaves weighed together. Sown May 19. Pulled November 9-13.

1927 : Oats (cut as hay and weighed green). Harvested September 8.

1928 : Seeds Hay. Cut June 22.

A	B	C	D
H	L	M	C
L	H	C	M
M	C	H	L
C	M	L	H

Block D was badly damaged by stray cow in 1927 and was not weighed. Remainder treated as 3 randomised blocks of 4 plots each.

Soil : Millstone grit.

SYSTEM OF REPLICATION : Latin Square.

Area of each plot : .02875 acre.

Previous manuring : 2 tons per acre lime ashes (70.80% lime), 1 cwt. Sulphate of Ammonia and 4 cwts. Kainit per acre for oats in 1925.

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 lbs. P_2O_5 per acre in April, 1926. Basal Dressing : ½ cwt. Sulphate of Ammonia and ½ cwt. Muriate of Potash per acre in 1926.

No manure in 1927 or 1928.

Actual Weights in lb.

	1926				1927				1928			
Block.	C	L	M	H	C	L	M	H	C	L	M	H
A	1019	918	1298	1069	472	400	365	372	158	155	185	163
B	1271	1246	1422	1327	360	382	427	382	218	190	212	198
C	1166	1175	1232	1378	409	364	448	381	146	189	165	176
D	1143	1164	1123	1313	—	—	—	—	155	184	170	191

Summary of Results.

Average Yield.		Control.	Low Soluble.	Med. Soluble.	High Soluble.	General Mean.	Standard Error.
1926	Swedes.						
	Tons per acre	17.85	17.48	19.70	19.75	18.85	0.52
	Per cent. ...	95.5	93.5	105.4	105.6	100.0	2.78
1927	Green Oats.						
	Cwt. per acre	128.5	118.6	128.4	117.5	123.2	7.41
	Per cent. ...	104.2	96.3	104.2	95.4	100.0	6.01
1928	Seeds Hay.						
	Cwt. per acre	52.6	55.7	56.8	56.5	55.4	1.38
	Per cent. ...	94.9	100.6	102.6	102.0	100.0	2.49

1926. Medium and high soluble slags show significant superiority over low.
1927. No significant response.
1928. Evidence of response to slags, which only approaches significance in the case of the medium soluble slag.

Potatoes : Effect of Sulphate of Ammonia and Sulphate of Potash, each in single and double dressings.

Mr. J. Luddington, Abbey Farm, Norfolk, 1928.

	A			B			C			
	N4 K0	N2 K0	N2 K4	N2 K0	N4 K2	N0 K0	N2 K0	N0 K4	N2 K2	
	N0 K4	N2 K2	N4 K2	N4 K4	N4 K0	N2 K4	N2 K4	N4 K4	N0 K0	
	N4 K4	N0 K0	N0 K2	N0 K2	N2 K2	N0 K4	N4 K0	N4 K2	N0 K2	
	N2 K2	N0 K2	N4 K0	N2 K2	N4 K2	N4 K0	N4 K4	N2 K2	N0 K2	
D	N4 K2	N2 K4	N0 K4	N2 K4	N2 K0	N0 K2	N0 K4	N2 K0	N2 K4	F
	N4 K4	N2 K0	N0 K0	N4 K4	N0 K0	N0 K4	N0 K0	N4 K0	N4 K2	
	N0 K0	N0 K2	N4 K0	N2 K0	N2 K4	N4 K4	N0 K4	N2 K4	N4 K2	
	N0 K4	N2 K0	N2 K2	N4 K2	N0 K2	N4 K0	N0 K0	N0 K2	N4 K0	
	N4 K4	N4 K2	N2 K4	N2 K2	N0 K0	N0 K4	N2 K2	N2 K0	N4 K4	
	G			H			J			

Variety : Majestic.

Soil : Black fen overlying clay.

System of Replication : 9 randomised blocks of 9 plots each.

Area of each plot : $\frac{1}{80}$ acre.

Treatments :

S/Amm. and S/Pot. at the rate of 0, 2 and 4 cwts. per acre, in all combinations.

Upper figure = amount of S/Amm.

Lower figure = amount of S/Pot.

Basal Manuring 4 cwt. Superphosphate per acre.

Manures applied : April 24.

Planted April 24 ; lifted October 1-2.

Actual Weights in lb.

Quantities of S/Amm.	Quantities of S/Pot.	A	B	C	D	E	F	G	H	J
0	0	157	230	201	246	226	203	286	181	201
0	2	215	219	233	184	209	254	217	162	192
0	4	258	267	209	192	197	217	187	288	180
2	0	329	250	295	270	271	379	254	276	254
2	2	261	301	289	257	281	269	232	228	230
2	4	263	374	180	259	312	240	239	240	204
4	0	273	323	222	271	311	172	300	313	276
4	2	309	286	244	299	327	297	308	286	260
4	4	268	238	265	289	314	248	258	283	306

(1) Summary of Average Yields.

Tons per acre.	No S/Amm.	2 cwt. S/Amm.	4 cwt. S/Amm.
No Potash ...	7.66	10.23	9.77
2 cwt. S/Pot....	7.48	9.32	10.38
4 cwt. S/Pot....	7.92	9.17	9.80

https://doi.org/10.23637/ERADOC-1-85

Potatoes, Abbey Farm, Norfolk (cont.)

(2) Summary of Significant Results.

Average Yield.	No S/Amm.	2 cwt. S/Amm.	4 cwt. S/Amm.	Mean.	Standard Error.
Tons per acre	7.69	9.57	9.98	9.08	0.26
Per cent.	84.7	105.4	109.9	100.0	2.87

Significant response to nitrogenous manure only. Potash produced no additional effect.

Potatoes : Effect of Superphosphate.

Mr. J. H. L. Luddington, Abbey Farm, Norfolk, 1928.

I	8	4	0	2
II	0	2	8	4
III	2	0	4	8
IV	4	8	2	0

Soil : Black fen overlying clay.

Variety : Majestic, planted April 24 ; lifted October 1-2.

System of Replication : Latin Square.

Area of each plot : $\frac{1}{32}$ acre.

Treatment : Superphosphate at the rate of 0, 2, 4 and 8 cwt. per acre. Basal Manuring : 2 cwts. S/Pot. and 2 cwt. S/Amm. per acre. Manures applied April 24.

Actual Weights in lb.

Rows.	0	2	4	8
I	651	706	743	866
II	520	740	780	901
III	505	674	744	813
IV	593	693	804	940

Summary of Results.

Average Yield.	No Super.	2 cwts. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre	8.10	10.05	10.97	12.57	10.42	0.33
Per cent. ...	77.8	96.4	105.2	120.6	100.0	3.21

Significant response to all applications of Superphosphate.

Potatoes : Effect of Superphosphate.

Mr. G. Major, Newton Farm, Lincs., 1928.

I	0	2	8	4
II	4	0	2	8
III	8	4	0	2
IV	2	8	4	0

VARIETY : King Edward, planted April 9 ; lifted October 3-4.

SYSTEM OF REPLICATION : Latin Square.

Area of plot : $\frac{1}{32}$ acre.

TREATMENT : Superphosphate at the rate of 0, 2, 4 and 8 cwt. per acre ; Basal Manuring 4 cwt. S/Pot. and 4 cwt. S/Amm. per acre.

Manures applied April 9.

Actual Weights in lb.

Row.	0	2	4	8
I	1225	1259	1225	1271
II	1207	1197	1324	1169
III	1154	1159	1208	1287
IV	1168	1236	1156	1244

Summary of Results.

Average Yield.	No Super.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre	16.98	17.32	17.55	17.75	17.40	0.27
Per cent. ...	97.6	99.6	100.8	102.0	100.0	1.54

The response to Superphosphate is small, only the 8 cwt. showing significant increase over control.

Sugar Beet : Comparison of Nitrogenous Fertilisers, Sulphate and Muriate of Ammonia.

Col. F. Wilson, Stanway Hall Farm, Colchester, 1927.

E.S.E.

I			II			III			IV		
B	A	C	B	C	A	C	B	A	A	C	B

TREATMENTS :
A = Control.
B = S/Amm. 2 cwt. with seed +1 cwt. Top Dressing per acre.
C = M/Amm. equivalent of S/Amm.
All plots had in addition a dressing of 3 cwts. Superphosphate. and $1\frac{1}{2}$ cwt. Muriate of Potash per acre.

VARIETY : Klein Wanzleben.
SYSTEM OF REPLICATION : 4 randomised blocks.
AREA OF EACH PLOT : $\frac{1}{20}$ acre.

Basal Manures applied May 1.
Top dressing applied second week in June.
Seed sown first week of May.
No farmyard manure.
Soil : Light sandy loam.

Actual Weights in lb.

Blocks.	A	B	C
I	750	896	705
II	935	983	991
III	921	854	753
IV	1008	1033	988

Summary of Results.

Average Yield.	Control.	S/Amm.	M/Amm.	General Mean.	Standard Error.
Tons per acre ...	8.07	8.41	7.67	8.05	0.30
Per cent. ...	100.2	104.5	95.3	100.0	3.47

No significant response to either treatment.

Sugar Beet : Comparison of Nitrogenous Fertilisers, Sulphate and Muriate of Ammonia, and Cyanamide.

Col. F. Wilson, Stanway Hall Farm, Colchester, 1928.

I	A	B	C	D	E
II	B	E	D	C	A
III	C	D	E	A	B
IV	D	A	B	E	C
V	E	C	A	B	D*

* This plot discarded and a value calculated for it from the other 24.

Soil : Light sandy loam.
VARIETY : Klein Wanzleben.
SYSTEM OF REPLICATION : Latin Square.
Area of each plot : $\frac{1}{40}$ acre.
A = Basal only, 4 cwt. Super and 2 cwt. S/Pot. per acre.
B = Basal+40 Nitrogen as Cyanamide+20 lb. as Nitrate of Soda with seed.
C = Basal+60 lb. of Nitrogen as Cyanamide.
D = Basal+60 lb. of Nitrogen as Muriate of Ammonia.
E = Basal+60 lb. of Nitrogen as Sulphate of Ammonia.
Cyanamide applied May 3. Other manures May 30-31.
Seed sown May 3. Lifted November 15.

Actual Yields in lb.

Row.	A	B	C	D	E
I	306	556	369	332	396
II	325	357	317	358	485
III	275	413	309	467	367
IV	453	389	335	418	324
V	346	397	572	464	503

Summary of Results.

Average Yield.	No Nitrogen.	Cyanamide Nit.Soda	Cyanamide alone.	M/Amm.	S/Amm.	General Mean.	Standard Error.
Tons per acre	6.09	7.54	6.79	7.28	7.41	7.00	0.26
Per cent.	86.7	107.4	96.7	103.7	105.5	100.0	3.74

Significant response to nitrogenous manures, except where all Nitrogen was applied as Cyanamide. This treatment was significantly below the mean of the others.

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, 1928.

Latin Square : Plots $\frac{1}{40}$ acre. Soil : Light gravelly loam.

Basal Manuring : 8 tons F.Y.M. in Autumn of 1927, 2 cwt. Sulphate of Ammonia and 2 cwt. Sulphate of Potash per acre.

Average Yield.	No Superphosphate.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre	15.78	15.62	16.12	16.03	15.89	0.36
Per cent. ...	99.3	98.3	101.5	100.9	100.0	2.27

No evidence of response to Superphosphate.

Potatoes. Mr. E. Arden, Owmby, Cliff, Lincolnshire, 1928.

Latin square : Plots $\frac{1}{45}$ acre. Soil : Cliff Land (Oölitic Limestone).

Basal Manuring : 2 cwt. Sulphate of Ammonia, 2 cwt. Sulphate of Potash per acre. Manures applied April 23.

Average Yield.	No Superphosphate.	2 cwt. Super.	4 cwt. Super.	8 cwt. Super.	Mean.	Standard Error.
Tons per acre ...	8.18	6.79	7.73	7.25	7.49	0.27
Per cent. ...	109.2	90.6	103.3	96.8	100.0	3.66

Significant depression due to the application of Superphosphate.

https://doi.org/10.23637/ERADOC-1-85

Sugar Beet. County School, Welshpool, Montgomeryshire, 1928.

Plots in triplicate : $\frac{1}{80}$ acre. Soil : School garden.

Basal Manuring : 10 tons F.Y.M. 3 cwt. Superphosphate, 1 cwt. Muriate of Potash per acre.

Manures applied May 10, except Nitrogenous, which were applied after singling (6 in. high) about June 20. Seed sown May 10. Lifted October 16.

Average Yield.	No Nitrogen.	Sulphate of Ammonia 2 cwt.	Muriate of Amm. = 2 cwt. Sulphate.	Mean.	Standard Error.
Roots, tons per acre ...	9.79	11.00	11.89	10.89	0.70
Roots, per cent. ...	89.8	101.0	109.2	100.0	6.45
Tops, tons per acre ...	14.00	18.90	20.67	17.86	1.00
Tops, per cent. ...	78.4	105.9	115.7	100.0	5.60

Significant response to Muriate with roots, and to Muriate and Sulphate with tops. The difference between the Sulphate and Muriate Plots is not significant.

Sugar Beet. South-Eastern Agricultural College, Wye, Kent, 1928.

Basal Manuring : 10 loads F.Y.M. in March, 4 cwt. Kainit (May 9) and 4 cwt. Superphosphate (May 19) per acre. Varieties : Dippe E and Strube's Green Top. Nitrogenous Manures applied May 19. Seed sown May 9. Roots lifted November 8. Plots in quadruplicate, each $\frac{1}{80}$ acre.

Average Yield in tons per acre.

Variety	No Nitrogen.	1 cwt. S/Amm.	Equiv. M/Amm.
Dippe	14.54	14.88	14.71
Strube	12.00	13.18	12.39

Sugar Percentage.

Variety.	No Nitrogen.	1 cwt. S/Amm.	Equiv. M/Amm.
Dippe	16.25	15.70	16.72
Strube	15.27	15.77	15.55

Lawes Agricultural Trust

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