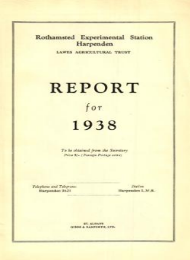
Rothamsted Report for 1938

Full Table of Content



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Rothamsted Experimental Station
Harpenden

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

REPORT
FOR
1938

CONTENTS

Experimental Station Staff

JANUARY—DECEMBER 1938

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

The James Mason Bacteriological Laboratory—

Head of Department	H. G. Thornton, B.A., D.Sc.
Assistant Bacteriologist	Hugh Nicol, Ph.D., F.I.C.
Post-Graduate Research Worker	Chen Hwa-Kuei, B.Sc.
Laboratory Assistant	Blanche Rolt
Laboratory Attendant	Mavis Grant

Botanical Laboratory—

Head of Department	Winifred E. Brenchley, D.Sc., F.L.S.
Assistant Botanist	Katherine Warington, D.Sc.
Laboratory Assistant	Marjorie Messenger
Laboratory Attendants	Ruth Walker
	Constance Hull

Chemical Laboratory—

Head of Department	E. M. Crowther, D.Sc., F.I.C.
Assistant Chemists	R. G. Warren, B.Sc.
	Signe G. Heintze, Mag. Phil.
	G. Nagelschmidt, Dr. Phil.
	J. B. Hale, Ph.D.
Post - Graduate Research Workers	G. W. Cooke, B.Sc.
	S. A. Ullah, Ph.D.
	B. N. Lal, B.Sc.
Special Assistant	E. Grey
Laboratory Assistants	A. H. Bowden
	F. J. Seabrook
	G. Lawrence
	H. A. Smith
	Joan Hellyer
	K. E. Clare
	Alice Kingham
	Elma MacInnes
Laboratory Attendant	Joan Chappin

Fermentation Laboratory—

Head of Department	E. H. Richards, B.Sc., F.I.C. (Iveagh Research Chemist)
Assistant Chemist	N. W. Barritt, M.A.
Post - Graduate Research Worker	N. S. Bamji, M.Sc.
Laboratory Attendant	Daphne Perry

General Microbiology Laboratory—

Head of Department . .	D. Ward Cutler, M.A., F.Z.S.
Assistant Microbiologists	Lettice M. Crump, M.Sc., F.Z.S. Jane Meiklejohn, Ph.D.
Post - Graduate Research Workers	B. N. Singh, M.Sc., Ph.D. Y. Hwang, Dr. Econ.
Laboratory Assistant . .	Mabel Dunkley

Insecticides and Fungicides Laboratory—

Head of Department . .	F. Tattersfield, D.Sc., F.I.C.
Assistant Chemists . .	J. T. Martin, Ph.D., A.I.C. S. H. Harper, Ph.D., A.R.C.S., D.I.C.
Entomologist	C. Potter, Ph.D., D.I.C.
Honorary Entomologist . .	Mrs. E. M. Potter, Ph.D., D.I.C.
Laboratory Assistants . .	J. R. Williams Marjorie Roberts
Laboratory Attendant . .	Mavis Grant

Physical Laboratory—

Head of Department . .	B. A. Keen, D.Sc., F.Inst.P., F.R.S.
Colloid Physicist	R. K. Schofield, M.A., Ph.D., F.Inst.P. (Empire Cotton Growing Corporation Soil Physicist)
Assistant Physicists . .	E. W. Russell, M.A., Ph.D., F.Inst.P. (Goldsmith's Company Physicist) G. H. Cashen, M.Sc. H. L. Penman, Ph.D., A.Inst.P.
Post - Graduate Research Workers	A. L. C. Davidson, B.Sc. S. P. Saric, B.Sc.
Assistant	Jessie Walker
Laboratory Assistants . .	W. C. Game R. Yates H. C. D. King Primrose Baty
Laboratory Attendant . .	Monica Waller

Statistical Laboratory—

Head of Department . .	F. Yates, Sc.D.
Assistant Statisticians . .	W. G. Cochran, M.A. J. W. Weil, M.A.
Post - Graduate Research Workers	D. A. Boyd, B.A. R. N. P. Luddington, B.A.
Assistant Computers . .	Peggy Hubbard Peggy Hurt Peggy McLarty Gladys A. Smith
Honorary Consultant . .	Prof. R. A. Fisher, M.A., Sc.D., F.R.S.

Entomological Laboratory—

Head of Department ..	C. B. Williams, M.A., Sc.D.
Assistant Entomologists ..	H. F. Barnes, M.A., Ph.D. A. C. Evans, Ph.D.
Soil Insects Investigations	P. S. Milne, B.Sc. H. C. Gough, Ph.D.
Migration of Insects ..	G. F. Cockbill, B.Sc.
Post-Graduate Research Workers	Betty J. Lovibond, B.Sc. J. Deal, M.A. E. R. Goodliffe, B.A.
Laboratory Assistants ..	Elizabeth Sibley Jean Pluck
Laboratory Attendants ..	Anita Newbury G. Everett
Bee Investigations—	
Apiarist	D. M. T. Morland, M.A.
Apicultural Assistant ..	A. C. Rolt

Plant Pathology Laboratory—

Head of Department ..	J. Henderson Smith, M.B., Ch.B., B.A.
Mycologist	S. D. Garrett, M.A.
Assistant Mycologist ..	Mary D. Glynne, M.Sc., F.L.S.
Virus Diseases: Special Staff—	
Physiologist	F. C. Bawden, M.A.
Cytologist	Frances M. L. Sheffield, Ph.D., F.L.S.
Entomologist	Marion A. Watson, Ph.D.
Assistant Entomologist	Florence M. Roberts, Ph.D.
Glasshouse Superintendent	Margaret M. Browne
Post-Graduate Research Workers	Lina Cunow Elizabeth M. Turner, B.A. A. G. Walker, B.Sc. T. S. Sadasivan, M.Sc. C. I. Shen, B.Sc. V. Kassanis
Laboratory Assistants ..	Stella Ward Margaret Blackstone
Laboratory Attendant ..	Gladys Custance
Glasshouse Assistants ..	Betty M. Brown A. W. Halsey

Field Experiments—

Guide Demonstrators . .	H. V. Garner, M.A., B.Sc. E. H. Gregory
Plant Physiologists . .	D. J. Watson, M.A., Ph.D. Prof. W. Southworth
Post - Graduate Research Worker	B. P. Akhaury, B.Sc. (Agric.)
Field Superintendent . .	B. Weston
Assistants	G. F. Cole S. A. W. French G. Weston

Imperial College of Science and Technology Staff—

(Plant Physiology) . .	F. G. Gregory, D.Sc. A. T. Legg F. J. Richards, M.Sc.
Assistants	A. R. Williams T. W. Missenden

Farm—

Manager	J. R. Moffatt, B.Sc. (Agric.), N.D.A.
Recorder	G. W. Wilcock, N.D.A.
Bailiff	H. Currant
Horsemen	F. Stokes C. Mepham W. Cain
Stockman	A. T. Smith
Tractor Driver	J. Underhill
Labourers	W. Holland H. Chapman E. Fox

Library—

Librarian	Mary S. Aslin
Assistant	Joan Corbett

Secretarial Staff—

Secretary	W. Barnicot, M.B.E.
Assistant Secretary . .	Constance K. Catton
Director's Private Secretary	Annie E. Mackness
Senior Clerk	Beatrice E. Allard
Junior Clerks	Olive Munt Margaret Bushell Betty Jackson

---

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

Members of Permanent Staff who left between January 1st and December 31st, 1938, and the Appointments to which they proceeded:

J. W. Dewis, B.Sc.,
Assistant Soil Analyst,
Land Fertility Scheme,
School of Agriculture,
Cambridge.

Miss Annie Dixon, M.Sc.,
To establish on her own account,
Batchwood Nursery,
Batchwood Drive,
St. Albans.

Mrs. K. J. Grant,
Went to China to be married to Dr. H. L. Richardson.

Miss Christine J. Goodey,
Assistant Librarian,
Geological Society,
Burlington House,
Piccadilly,
London.

A. F. Howell, B.Sc. (Agric.),
Chadacre Agricultural Institute,
Hartest,
Bury St. Edmunds.

S. H. Jenkins, Ph.D., F.I.C.,
Chemist to the
Birmingham, Tame and Rea District Drainage Board,
Rookery Park,
Erdington,
Birmingham.

W. R. S. Ladell, F.I.C.,
Agronomist and Soil Chemist,
West Indies Sugar Company,
Jamaica.

H. L. A. Tarr, M.A., Ph.D.,
Bacteriologist,
Fisheries Experiment Station,
Prince Rupert,
British Columbia.

T. G. Tomlinson, M.Sc.,
Assistant Bacteriologist,
Water Pollution Research Laboratory,
Drainage Board Works,
Kingsbury Road,
Minworth,
Nr. Birmingham.

R. Wilkinson, M.Sc.,
Assistant Chemist,
Water Pollution Research Laboratory,
Drainage Board Works,
Kingsbury Road,
Minworth,
Nr. Birmingham.

Temporary Workers, 1938—

In addition to those temporary workers recorded in the list of staff, the following sent officially by Governments or Universities, or who have come on their own resources, have worked at the Station for varying periods during the year 1938.

(1) FROM THE EMPIRE:

Australia: W. M. Holman, J. M. Vincent.
India: S. P. Capoor, M. O. Ghani, E. S. Narayan, C. C. Sekar, R. V. Tamhane, K. N. Trehan.
New Zealand: Dr. L. A. Whelan.

(2) FROM FOREIGN COUNTRIES:

Argentine: Dr. A. Arena.
Denmark: A. V. Jorgensen.
France: J. Hara, Miss C. Magnant.
Japan: Prof. H. J. Murata.
Switzerland: Miss de Regel.
United States of America: Prof. T. J. Dannewald.

(3) FROM BRITISH ISLES:

E. M. Carpenter, A. R. Cottrell, C. E. Ford, Miss E. Glenn, I. S. Genussow, J. Hewitt, J. Wyatt Smith, D. C. Thomas.

Woburn Experimental Farm

Aspley Guise, Bletchley, Beds.

Telephone & Telegrams:
Ridgmont 30.

Station:
Ridgmont, L.M.S.

Assistant Director ..	H. H. MANN, D.Sc., F.I.C. (Kaisar-i-Hind Gold Medal)
Chemist	T. W. BARNES, M.Sc., F.I.C.
Laboratory Assistant ..	D. WOOD

Farm Staff—

Foreman and Stockman	W. McCALLUM
Horseman	G. TYLER
Stockmen	W. A. McCALLUM R. PEARCE
Labourers	A. SIBLEY T. EVANS

Imperial Bureau of Soil Science

Director : Sir E. J. Russell, D.Sc., F.R.S.
Deputy Director : G. V. Jacks, M.A., B.Sc.
Scientific Assistants : A. J. Lloyd Lawrence, M.A.
Helen Scherbatoff
Assistant Abstractors : Janet N. Combe
Beryl M. North
Secretary : Mary Ellingham
Clerks : Joan Saunders, Myrtle Staines

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

A quarterly abstract journal, Soils and Fertilizers, covering the literature of soil science, fertilizers and the culture of field crops throughout the world is published, together with occasional monographs — Technical Communications — on subjects of general interest.

Publications of the Rothamsted Experimental Station

For Farmers

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

" ARTIFICIAL FERTILIZERS IN MODERN AGRICULTURE," by Sir E. J. Russell, D.Sc., F.R.S. Bulletin No. 28, Ministry of Agriculture and Fisheries, Third Edition, revised 1939. H.M. Stationery Office, or from the Secretary, Rothamsted Experimental Station, Harpenden. Cloth, 4/6 post free, or paper cover 3/5 post free.

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

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

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* Out of print in separate copies, but obtainable in bound volumes.

Numbers 1 to 20 inclusive are also published in book form with the exception of 1-5 (Vol. I), which is out of print. Vol. II (6-10), Vol. III (11-15), Vol. IV (16-20), 10/- each, postage extra.

For Students and Agricultural Experts

"THE ROTHAMSTED MEMOIRS ON AGRICULTURAL SCIENCE." Quarto Series, vol. 4 (1914-1934), 20/-. Octavo Series, vols. 1-7 (1847-1898), 30/- each. Royal Octavo, vol. 8 (1900-1912), vol. 9 (1909-1916), vol. 10 (1916-1920), vol. 11 (1920-1922), 32/6 each, vol. 12 (1922-1925), vol. 13 (1925-1927), 33/6 each, vol. 14 (1928-1930), 35/-, vol. 15 (1922-1931), vol. 16 (1922-1932), vol. 17 (1931-1933), vol. 18 (1923-1934), vol. 19 (1933-1935), vol. 20 (1935-1936), vol. 21 (1936-1937), 36/- each. Foreign postage extra. Obtainable from the Secretary, Rothamsted Experimental Station, Harpenden, Herts.

"THE ROTHAMSTED MONOGRAPHS ON AGRICULTURAL SCIENCE," edited by Sir E. J. Russell, D.Sc., F.R.S.

"SOIL CONDITIONS AND PLANT GROWTH," by E. J. Russell. D.Sc., F.R.S. Seventh Edition, 1937. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 21/-.

"THE MICRO-ORGANISMS OF THE SOIL," by E. J. Russell and Staff of the Rothamsted Experimental Station, 1923. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 7/6.

"MANURING OF GRASSLAND FOR HAY," by Winifred E. Brenchley, D.Sc., F.L.S. 1924. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 12/6.

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

"THE PHYSICAL PROPERTIES OF THE SOIL," by B. A. Keen, D.Sc., F.R.S. 1931. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 21/-.

"PROBLEMS IN SOIL MICROBIOLOGY," by D. Ward Cutler, M.A., and Lettice M. Crump, M.Sc. 1935. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 9/-.

"FIFTY YEARS OF FIELD EXPERIMENTS AT THE WOBURN EXPERIMENTAL STATION," by E. J. Russell, D.Sc., F.R.S., and J. A. Voelcker, C.I.E., M.A., Ph.D., with a Statistical Report by W. G. Cochran, M.A. (Rothamsted Statistical Department). 1936. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 21/-.

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

"Report on the Work of the Imperial Council of Agricultural Research in Applying Science to Crop Production in India," by Sir John Russell, D.Sc., F.R.S. Reprinted Edition, 1939. Government of India Press, Simla. 3/3. Obtainable from the High Commissioner for India, India House, Aldwych, London, W.C.2.

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

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 Farm, Rothamsted."

"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). 1926. 331 pp. 22 illustrations. Cloth cover, 12/- ; paper cover, 10/-. Packing and postage extra :—British Isles. 9d.; Overseas, Dominions and other countries, 1/3.

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For Use in Farm Institutes

"A Student's Book on Soils and Manures," by E. J. Russell, D.Sc., F.R.S. The University Press, Cambridge. 8/-.

For Use in Schools

"Lessons on Soil," by E. J. Russell, D.Sc., F.R.S. 1926. The University Press, Cambridge. 3/-.

For General Readers

"THE FARM AND THE NATION," by E. J. Russell, D.Sc., F.R.S. 1933. George Allen and Unwin, Ltd., 40 Museum Street, London, W.C.1. 7/6.

"THE FERTILITY OF THE SOIL," by E. J. Russell, D.Sc., F.R.S. 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. 1/-. 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.

"COTTAGE LIFE IN A HERTFORDSHIRE VILLAGE," by E. Grey. 1935. A companion volume to "PERSONAL REMINISCENCES OF ROTHAMSTED EXPERIMENTAL STATION." Fisher, Knight & Co., St. Albans, 3/6. 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. 1932. Christophers, 22 Berners Street, London, W.1. 4/6.

"STATISTICAL TABLES FOR BIOLOGICAL, MEDICAL AND AGRICULTURAL RESEARCH," by R. A. Fisher, M.A., Sc.D., F.R.S., and F. Yates, Sc.D. 1938. Oliver & Boyd, Edinburgh. 12/6.

"PLANT GROWTH SUBSTANCES," by Hugh Nicol, Ph.D., F.I.C. 1938. Leonard Hill, Ltd., 17, Stratford Place, London, W.1. 3/6.

Mezzotint Engravings

Mezzotint Engravings of Portraits of the Founders of the Station, Sir J. B. Lawes (H. Herkomer) and Sir J. H. Gilbert (F. O. Salisbury), by Julia Clutterbuck, A.R.E.
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Plans and Drawings of the old Rothamsted Laboratory, 1852

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

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

INTRODUCTION

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

For many years the work was maintained entirely at the expense of Sir J. B. Lawes, at first by direct payment, and from 1889 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 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 1938-39, the Ministry of Agriculture has made a grant of £29,095 for the work of the Station. Lord Iveagh has generously borne the cost of a chemist and a special assistant for field experiments for studying farmyard manure, both natural and artificial; while other donors have, from time to time, generously provided funds for special apparatus and equipment. The Fertiliser Manufacturers' Association and the United Potash Company provide considerable funds for the rather expensive field work. Imperial Chemical Industries, and the Association of British Chemical Manufacturers, have provided a special assistant for the study of soil insecticides. In addition, British Sugar Corporation, British Basic Slag Companies, the Royal Agricultural Society, Dunlop Plantations, Ltd., the Institute of Brewing, United Africa Company, Trustees of the late Viscount Leverhulme, the Department of Scientific and Industrial Research and other bodies have made grants for specific purposes. In 1938 a grant was made jointly from the Colonial Development Fund and from the Ministry of Agriculture for the extension of the work on vegetable insecticides. The result is that the Station is able to deal with problems affecting modern farming in a far more complete manner than would otherwise be possible.

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

Large glasshouses, including special insect-proof houses for virus studies, were added in 1926, 1928, and 1931 by aid of generous grants from the Rockefeller Foundation, the Empire Marketing Board and the Ministry of Agriculture. A new large range of houses, some of which are insect-proof, was erected in 1935 for Plant Pathology investigations at a total cost of £2,283, towards the cost of which the Ministry of Agriculture made a grant of £1,025.

From 1926 onwards great changes took place on the farm. New and greatly improved methods of field experimentation were adopted on all but the classical plots, which remain essentially unchanged ; and the non-experimental part of the farm was reorganized in 1928, considerable numbers of live stock being introduced, and much of the land being laid down to grass. The farm buildings were considerably enlarged in 1930 with the aid of a grant of £1,700 given by the Ministry of Agriculture and a new block of buildings containing a demonstration room, work-rooms for the experimental staff, office and store-rooms was erected in 1931-32 at a cost of £1,300 collected by public subscription. In 1936 a pair of cottages for farm workers was erected at a cost of £1,050. A special building was also constructed in which both farmyard manure and "artificial" farmyard manure can be produced under standardised conditions ; the cost was £275, towards which Lord Iveagh contributed £100.

During 1932, the farm was well equipped with electrical appliances, thanks to generous assistance by the General Electric Company and the North Metropolitan Electric Power Supply Company. The Dunlop Rubber Company also provided rubber equipment, including a rubber road, rubber flooring for cattle and pig pens, and rubber tyres for cart and tractor.

The Library is steadily growing, and now contains some 27,000 volumes dealing with agriculture and cognate subjects. The catalogue of the old printed books on agriculture was published in 1926, and every effort is made to obtain any that we do not possess. A collection is also being made of prints of farm animals, of old letters on agriculture, farm account books, and models of old farm wagons. Many of these lie in farmhouses, unused and inaccessible, not in themselves valuable, but often a great help to students of agricultural history and economics when brought together as we are doing. Gifts of books and documents to the Library will be greatly appreciated.

The extension of the experiments to various outside centres in Great Britain, begun in 1921, has proved so advantageous that it has been developed. Not only is useful information spread among farmers, but the Station itself gains considerably by this closer association with practical men. As part of this extension the Station took over in 1926 the Woburn Experimental Farm. We were thus able to make experiments simultaneously on the light land at Woburn and the heavy land at Rothamsted : a very advantageous arrangement. The Assistant Director in charge is Dr. H. H. Mann, with Mr. T. W. Barnes as chemist.

In May, 1934, the negotiations for the purchase of the farm and some adjoining parts of the Rothamsted estate were completed. This step was necessary owing to building developments in Harpenden that threatened to extend over the estate. We held the farm lands only on lease ; some on a yearly tenancy, and some at shorter notice. Even the land on which the laboratories are built and the sites of the classical fields did not belong to us. The Rothamsted Trustees now own the site of the laboratories, the experimental and ordinary farm fields, Knott Wood, the Manor House and grounds, the farm manager's house and eight cottages. The total area is 527 acres, sufficient for carrying out field and farm experiments on a scale corresponding to the importance of the work. The purchase price was £35,000, all of which was raised by public subscription in eight weeks. Generous contributions were received from Sir Robert McDougall, the Sir Halley Stewart Trust, the Carnegie Trustees, Sir Bernard Greenwell, Bart., the Royal Agricultural Society, the National Farmers' Union, and Imperial Chemical Industries. A highly encouraging feature of the appeal was the number of subscriptions received from farmers, village school teachers, and from overseas sources.

The activities of Rothamsted, however, are not confined to the British Isles, but are gradually spreading out to the Empire and other countries abroad. The International Educational 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. The Station regularly participates in work for the solution of certain agricultural problems of great importance to the Empire.

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

More and more workers are coming from the overseas Dominions to carry on their studies at Rothamsted. Only 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.

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

ROTHAMSTED REPORT FOR 1938

The outstanding event of 1938 was the inauguration of the arrangements for celebrating the centenary in 1943. As Rothamsted is by far the oldest existing agricultural station, the centenary will be an historic event of world-wide interest and the preparations must begin in ample time. The Committee has decided that the celebration shall take the form of putting the laboratories, equipment and farm and other buildings into proper order as far as possible for the thorough carrying out of the work, and of adding to the endowment a sum sufficient to ensure proper maintenance of the fabric and to permit certain essential salary augmentations. An Inaugural Meeting was called on November 1st, 1938, at which H.R.H. the Duke of Kent presided. H.M. the King opened the subscription list, and promises and donations amounting to £31,000 were announced. The fund has since grown and on June 12th 1939 it stood at £37,100 of which £10,000 is earmarked for special purposes. The clouded international situation has hindered operations, but a start has already been made in erecting proper laboratories for the chemical, biochemical and bacteriological workers. Later on it is hoped to provide for more pot culture houses, the extension of the farm buildings and the laying out of the fore-court. The total cost of this part is to be about £47,000 of which some £14,500 is found by the Ministry of Agriculture and some £31,000 from the Centenary Fund.

The need for the extensions is very great: the departments concerned have hitherto been working under serious disadvantages, which have prevented them from accomplishing as much as they would have liked.

THE WORK OF THE STATION: WORK AT HOME

The purpose of the work is to provide the basis for improving and developing agriculture and for raising the standard of country life. Agriculture, however, is so complex, and its practices are so diverse, varying so much according to local conditions, that it is quite impossible to lay down rules for universal adoption. Throughout Great Britain there are County Organisers and Local Advisory Experts who keep in touch with individual farmers and give them the best advice available in regard to their difficulties. The function of Rothamsted is to provide trustworthy information about soils, crops, fertilizers, diseases and pests of crops, and generally any subject connected with soil management and crop production: and to put this information into forms in which County Organisers, experts and good farmers can use it.

The information is obtained in the laboratories, pot-culture houses and experimental fields. The key experiments are made at Rothamsted on heavy soil and at Woburn on light soil, and in order to find the further effects of soil and weather conditions, selected experiments are repeated on good commercial farms in different parts of the country. We owe a great deal to those farmers who, at much inconvenience to themselves, allow us to make these experiments in their fields under conditions of good practice.

These outside field experiments are a vitally important part of our work and we are hoping to extend them so as to strengthen still further the links between the research workers and the advisory staffs. The experiments are designed, and the results worked out, by the Chemical and Statistical Departments, and the carrying out of the experiments is in charge of Mr. H. V. Garner, to whom much of the success of the scheme is due.

EXPERIMENTS AT OUTSIDE CENTRES

During 1938 the following crops came under experiment at the centres indicated and with the valuable field assistance of the experimenters named.

Potatoes. Balance of manures (three levels of nitrogen, phosphate and potash in all their 27 combinations).

Isle of Ely—Mr. W. E. Morton.

Sugar beet. (*a*) Response to three levels of nitrogen, phosphate and potash in all their 27 combinations.

East Lothian—in conjunction with the staff of the Cupar Sugar Factory.
Essex—Felstead Sugar Factory.
Fife—Cupar Sugar Factory.
Isle of Ely (two centres)—Ely and Peterborough Factories.
Lincolnshire (seven centres)—Bardney, Brigg, Newark, Spalding, Sugar Factories.
Norfolk (seven centres)—Cantley, King's Lynn, and Wissington Sugar Factories.
Nottingham—Colwick Sugar Factory.
Northampton—Peterborough Sugar Factory.
Shropshire (two centres)—Allscott Sugar Factory.
Suffolk (four centres)—Bury St. Edmunds and Ipswich Sugar Factories.
Worcestershire—Kidderminster Sugar Factory.
Yorkshire (three centres)—Poppleton and Selby Sugar Factories.

(*b*) Time of lifting and effect of fertilisers.

Lincolnshire—Spalding Sugar Factory.
Norfolk (two centres)—Cantley Sugar Factory.
Suffolk—Bury St. Edmunds Sugar Factory.

(*c*) Ploughing in of fertilisers.

Suffolk—Mr. A. W. Oldershaw.

(*d*) Residues of Chalk applied in 1932.

Suffolk—Mr. A. W. Oldershaw.

(*e*) Other experiments were carried out :

Lincolnshire—Lindsey County Council, Brigg and Bardney Sugar Factories.
Norfolk—Wissington Sugar Factory.
Nottingham—Newark Sugar Factory.

Poultry Manure Experiments. Ministry of Agriculture Scheme. The fertilising value of poultry manure and its cumulative and residual effects.

Bedfordshire—Mr. J. W. Dallas. Vegetable Marrows.
Berkshire—Prof. R. H. Stoughton. Chrysanthemums, Strawberries.
Bristol Province—Mr. A. W. Ling. Early Potatoes.
Kent—Dr. K. Barratt. Onions.

Small scale trials testing the cumulative effect of poultry manure were made at eighteen schools in various parts of the British Isles.

Basic Slag Committee Experiments.

Residual effects of phosphates measured in Oats and Hay.
West of Scotland—Prof. D. N. McArthur.

Experiments on Organic Manures.

Kent—Mr. G. Ossenton. Mangolds.
Suffolk—Mr. A. W. Oldershaw. Potatoes.
Sussex—Land Settlement Association. Potatoes.

The dissemination of the information gained by these various experiments is effected by writings, lectures or addresses, broadcast talks and visits of various kinds. Much of the lecturing is done by Mr. Garner, but other members of the staff share it with him, and so far as is practicable a lecture visit is combined with visits to farms in the district.

The justification for these extensions is that agricultural research work cannot be regarded as complete until it has found a way into current teaching or practice, and the first steps must be taken by the Research Institute itself. The work gains considerably thereby, for it often happens that considerable extensions are opened up through the observation and criticism of the advisors and farmers. A good example is afforded by the discovery in the Botanical Department at Rothamsted in 1923 that small quantities of boron are essential to the growth of certain plants. This was at first regarded rather as a scientific curiosity till agricultural experts in various parts of the world learned the symptoms of boron deficiency and found that it was widely spread, and was the cause of certain plant diseases that had caused a good deal of trouble. Once the cause was discovered the remedy was easily applied, and now these diseases are well under control. But the diseases and the associated problems of the practical growers have opened up a new lot of scientific problems and shown that the subject is much wider than was first suspected. Many of these diseases occur overseas, e.g. in New Zealand, Australia, the United States, and the investigations made in these countries have proved very helpful to agricultural experts in Great Britain in showing them what to look for.

OVERSEAS WORK, AND LINKS WITH OTHER AGRICULTURAL RESEARCH STATIONS

The overseas activities of Rothamsted began in 1923 when the Director was invited jointly by the Sudan Government and the Empire Cotton Growing Corporation to visit the Sudan and advise in regard to agricultural developments and scientific services. Subsequent visits of a similar nature have been made to other parts of Africa, Palestine, Australia, New Zealand, Canada, India, and outside the Empire, the United States and European countries including Russia. In addition a good deal of experimental work in parts of the tropical Empire is organised or directed from Rothamsted, and this has in several cases led to the transfer of Rothamsted workers to large planting organisations overseas. The old methods of plot experiments had in many cases proved unhelpful, but the new methods worked out at Rothamsted from 1926 onwards have proved of great value and are now widely adopted in Africa, India, Malaya, Ceylon and elsewhere. They have the great merit of giving results of known validity, so that the magnitude of the experimental error can be estimated, and in consequence the experimenter knows how much importance attaches to each figure in his results. Dr. W. B. Haines in 1927 gave up his post at Rothamsted to carry out experiments on the growth of rubber in Malaya, remaining in close association, however, with the chemical and statistical departments. His work has already had a marked effect in showing how the rubber trees should be manured. Dr. H. J. Page, formerly head of our Chemical Department, has accepted the Directorship of the Rubber Research Institute in Malaya, thus ensuring close touch between their workers and ours. A visit by Dr. Crowther in 1938 still further strengthened the connections. Dr. T. Eden left Rothamsted in 1927 for the Tea Research Institute in Ceylon and by suitably applying the new field plot technique has succeeded in obtaining valuable information about the manuring of tea which the older methods never could have given, in view of the difficulties such as steeply sloping ground, etc. All the important sugar cane experiments in India are laid out on the modern lines discussed in our laboratories with Dr. Vaidyanathan and others responsible for their performance. This use of Rothamsted methods and of Rothamsted results has led to invitations to members of the staff to visit overseas countries for purposes of discussion with the experts there: during 1938 the Director was invited to Australia and Ceylon; Dr. Crowther was invited to plan experiments on the manuring of oil palm and to visit West Africa as expert attached to the Leverhulme Commission; Mr. Cochran was invited to the United States to lecture on the recent application of statistical methods to agricultural problems: in addition Dr. Mann went to New Zealand. Quite apart from the many advantages of rendering service to the large planting organisations operating overseas, but centred in England, and of returning courtesies to the United States and European Universities and experiment stations which are invariably willing to help us—apart from all this the Rothamsted work gains enormously by these visits: the methods and results are criticised by really competent experts and new ideas emerge. In all scientific work, and especially in agricultural science, it is the new idea that counts: and whether it was acquired in Africa, America, or at home is of secondary importance.

THE LESSON FOR THE BRITISH FARMER

One impression comes out very definitely from these overseas visits. Farmers in every exporting country are casting longing eyes on the English market, and their expert advisors are doing their best to help them secure a place. English farmers can keep their position only by maintaining a high standard of efficiency, for it is certain that no protection would long be given to an inefficient industry.

GRASSLAND

Numerous experiments are made on grassland. For some years these were chiefly concerned with basic slag and were carried out under the aegis of the Basic Slag Committee of the Ministry of

Agriculture, but this has unfortunately come to an end with the setting up of the Land Fertility Committee. Although much remains to be done there is at present no research work on basic slag. The present grassland experiments are concerned with the effect of fertilisers on the yield and botanical composition of hay (studied in the Botanical Department) and with the effect of cake fed to grazing animals on the feeding value of pasture land.

THE CROPPING OF PLOUGHED-UP GRASSLAND

An investigation of special interest has been begun to study various ways of rapidly converting grassland into arable land with a view to the fullest utilisation of its stored-up fertility.

During the period that the land has lain in grass it has accumulated fertility and this is liberated when the land is ploughed up. A field experiment of special interest has been started to find how best the fertility can be utilised: several different first crops are being tried. Considerable work is being done on another problem of particular importance, while it was in grass the land accumulated not only fertility but usually also accumulated insect pests, especially wire worms, which may do great damage, sometimes almost ruining the first crop. The possibility of controlling wire worms by soil insecticides has been under investigation since January, 1934, by Major W. R. S. Ladell, but he left in April, 1938 to take the post of Agronomist and Soil Chemist to the West India Sugar Company, Jamaica; the work was then continued by Messrs. P. S. Milne and H. G. Gough. The problem is difficult but not by any means hopeless.

CONTINUOUS WHEAT GROWING

The wheat consumption of the United Kingdom is about 6½ million tons per annum, of which about 1½ million tons are produced at home and the rest is imported. The need for ensuring that the home production shall not fall below its present level has led to the adoption of certain financial devices, and the possibility that a higher home production might be needed has opened up certain technical problems.

Increased wheat production could be brought about in two ways: by more frequent growth of wheat on existing arable land, and by ploughing grassland and sowing it with wheat. For various reasons the former is the easier. Valuable information on this subject is furnished by the Broadbalk wheat field at Rothamsted on which wheat has been grown for nearly 100 years; its history is very instructive. The field has long been arable land: it appears so on the estate map of 1620 when it had the same boundaries as now, though it was called Sheepcote field and not Broadbalk. Its soil is heavy but it never had much reputation for fertility and at the outset of the experiments it yielded about 20 bushels of wheat per acre. In 1839 it was given a dressing of farmyard manure for the turnip crop: this was succeeded in 1840 by barley, in 1841 by peas, in 1842 by wheat and 1843 oats; then in October, 1843, the field was sown with wheat, and it has been cropped with wheat each year ever since: the ninety-fifth successive crop was harvested in August,

1938. No farmyard manure has been applied since 1839 except to one plot, nor has there been any green manure or any sort of organic manure. One plot has been without manure since 1839 and this has now reached its hundredth year of abstinence. Other crops have received various combinations of artificial fertilisers, the same combination every year since 1843 on some plots and since 1852 on the others, so as to allow the study of any cumulative effects either on the soil or on the crop. In the early years there were many who thought this continued use of artificials in the large quantities given—on some plots over 10 cwts. per acre—would poison the soil and ruin the crop ; the grain, it was supposed, would be lacking in quality or nutritive value as the result of this supposed unnatural method of growth.

For many years none of these things happened, except that the yield on the unmanured plot fell to about 12 bushels per acre, and that on the plots without nitrogen was but little better. There was no indication of any deterioration of the grain.

After a time, however, weeds began to be troublesome. In those days abundant child labour was available and there was much hand weeding, but later on labour was not obtainable and the fields became in some years badly infested. The trouble was particularly marked during the War and for a time afterwards, when great difficulty was experienced in keeping the experiment going : for some years the unmanured plot yielded only about 9 bushels per acre, and those receiving farmyard manure or complete artificials about 30 bushels per acre. From time to time attempts were made to deal with the weed problem by partial fallows : in 1889 and 1890 by wide rows over half of the plot to permit of hoeing ; and in 1914 one half of each plot was fallowed, and the other half in the following year ; in 1925 a rotating fallow was introduced which became regularised by 1930-31, one fifth of each plot being fallowed in the transverse direction and the remaining four-fifths cropped. The fallow kept down the weeds for one year but not, so far as could be judged, for much longer. The fundamental difficulty is that the short interval between harvesting of one crop and sowing the next allows so little time for cultivation ; weed seeds, especially of the black bent (*Alopecurus agrestis*) remain in the soil till the wheat is sown. Cultivation has now, however, been greatly speeded up with the aid of the tractor. Whether it is this factor or some peculiarity of the season 1937-38 we are not prepared to say, but certainly the yields on Broadbalk in 1938 were exceptionally high, such as had not been attained for many years on any plot and on some they were the highest yields ever recorded. In particular the plot which has had no manure for 100 years gave no less than 39 bushels per acre on the part that had been fallowed during 1937 and the remaining parts averaged 20 bushels per acre.

Only time will show whether the yields of 1938 can be repeated, but the experiment proves clearly that wheat can if desired be grown continuously on the same land. Why then is it that difficulties arise when wheat is grown continuously on mechanised farms ? The answer is probably to be found in the nature of the soil. On the heavy Broadbalk Soil the wheat crop remains healthy. Diseases and pests are, of course, present, but they usually do but little harm. The lighter soils, however, and especially the light chalky soils on which the mechanised farms are so often situated, are much more liable to certain fungus diseases such as Take-all, lodging diseases (*Cercosporella*) and others. Mr. Garrett is studying these diseases with a view to finding some method of control: if this can be done continuous or very frequent wheat growing with suitable artificial fertilisers, but without farmyard manure, should become possible on a wide scale.

TABLE I

Yields of Wheat, Broadbalk
Bushels dressed grain, per acre

Plot	Annual treatment	20 years' average 1852-1871	10 years' average 1928-1937		1938	
			All sections	Excluding sections following fallow	All sections	Excluding sections following fallow
3	No manure	15.2	13.5	8.9	24.6	19.8
	Complete artificials					
6	1 dose nitrogen ..	26.5	21.2	15.4	40.2	34.7
7	2 doses nitrogen ..	35.3	27.4	21.9	48.5	45.2
8	3 doses nitrogen ..	38.3	28.2	24.1	55.9	52.8
2	Farmyard manure	35.9	24.9	21.5	55.3	49.3

It is sometimes stated that wheat grown in this way without organic manure has less nutritive value than wheat grown with it. The Broadbalk experiments afford no evidence of this claim. Samples of grain from the different plots were sent to the Dunn Nutritional laboratories at Cambridge and examined by Dr. Harris, but no consistent difference in their content of Vitamin B^1 could be found. Nor have the milling or baking tests ever shown any superiority of organic over inorganic manure. The claim is also made in regard to other crops: fruit, vegetables, tea, etc.: but no good experiments have shown any difference. Bad misuse of artificial fertilisers may of course lead to loss of quality of produce and it is well known that farmyard manure has various beneficial effects on the soil.

FALLOW AS PREPARATION FOR WHEAT

COMPARISON OF A ONE-YEAR FALLOW WITH A THREE-YEAR FALLOW; HOOSFIELD

The yields of Broadbalk wheat in 1930 showed a remarkable response to a previous two-year fallow and on most plots a further response to a four-year fallow. The effects were most marked on the plots receiving no nitrogen; in particular, the yields on the continuously unmanured plots were:

Wheat grain : cwt. per acre
following

Wheat		Two years' fallow		Four years' fallow
3.3	4.5	16.4	12.9	20.4

To study this effect further, a comparison of the effect of a one-year fallow with that of a three-year fallow was included in the unmanured wheat plots on Hoosfield from 1934 onwards.

TABLE II

Wheat after fallow : Hoosfield

Grain : cwt. per acre

	Three-year fallow	One-year fallow		One-year fallow Broadbalk
			Mean	
1934	16.8*	12.3, 17.2	14.8	18.4
1935	9.7	6.3, 3.7	5.0	12.4
1936	2.9	5.0, 2.8	3.9	5.7
1937	4.8	4.8, 6.0	5.4	5.4
1938	17.7	17.0, 19.2	18.1	22.5

* Two years' fallow.

Except possibly in 1935, the beneficial effect ot a three-year fallow was no greater than that of a one-year fallow. It is uncertain how effective the one-year fallow was in these years, since there are no plots on this field without fallow, but it may be noted that on the corresponding plots on Broadbalk a one-year fallow produced an increase in yields in all these years except 1936. The Broadbalk yields after a one-year fallow are, however, fairly consistently above these on Hoosfield.

The Hoosfield results are supported by those on the unmanured plots on Broadbalk, in which on the average of these seasons the yields following a fallow two years previously were no higher than those following a fallow three or four years previously.

TABLE III

Broadbalk wheat, grain : cwt. per acre

Plot 3 (no manure)

	Year after fallow			
	1	2	3	4
1934	18.4	10.5	9.9	13.2
1935	12.4	3.0	3.1	5.8
1936	5.7	4.9	4.4	6.2
1937	5.4	5.2	6.7	3.1
1938	22.5	11.0	12.4	11.7
Mean	12.9	6.9	7.3	8.0

The indications on both fields are that in most seasons no marked effect of a fallow is detectable after more than one year.

EFFECTS OF TEMPORARY LEYS AND GREEN MANURES PRECEDING WHEAT

Clover, ryegrass and a clover-ryegrass mixture were compared with fallow as temporary leys preceding wheat in three experiments at Rothamsted during 1931-33, 1934-36 and 1936-38 respectively. The leys were sown under barley and cut in mid-summer in the following season.

TABLE IV

Effects of undersowing of leys on barley grain

Barley grain : cwt. per acre

	No ley	Undersown with Clover	Clover-Ryegrass	Ryegrass	S.E.
1931	16.1	17.3	16.0	15.8	±0.80
1936	24.8	26.6	23.7	25.2	±0.96

The yields of barley were not recorded in 1934. In the other years there was no evidence of any deleterious effect of undersowing on the barley.

After the first cut of leys some plots were ploughed while on others a second cut of the leys was taken. The yields of dry matter of the leys are shown below.

TABLE V

Dry matter : cwt. per acre

		Clover	Clover-Ryegrass	Ryegrass
1932	First cut ..	19.6	37.9	27.8
	Second cut ..	7.7	12.8	2.9
1935	First cut ..	27.3	30.6	12.8
	Second cut ..	10.6	8.9	2.2
1937	First cut ..	30.4	46.5	34.8
	Second cut ..	18.1	13.6	4.2

The clover-ryegrass mixture gave consistently the most substantial crop. Clover had about the same total yield as ryegrass in 1932 but a much higher yield in 1935 and 1937. The yields at the second cuts were much smaller than at the first cuts, particularly so with ryegrass. The 1937 experiment also contained a spring dressing of sulphate of ammonia (0.3 cwt. N per acre) to the leys. This had no effect on clover but increased the clover-ryegrass mixture by 8 cwt. and ryegrass alone by 24 cwt. per acre.

TABLE VI

Average effects of fallow and leys on wheat

Grain : cwt. per acre

	Preceding crop Fallow	Clover	Clover-Ryegrass	Ryegrass	S.E.
1933	30.4	25.6	20.7	16.4	±0.472
1936	16.4	12.7	12.4	11.0	±0.518
1938	36.3	33.6	27.6	26.2	±0.453

All three leys decreased the yields of wheat as compared with fallow. In each case the smallest decrease occurred after clover and the largest after ryegrass. The decreases with clover ranged from 3 to 5 cwt. per acre. The decreases with the other leys were little greater than with clover in 1936 on a poor crop of wheat, but in the other two years they averaged 9.2 cwt. per acre with the clover-ryegrass mixture and 12.0 cwt. per acre with ryegrass.

The experiments also contained a spring dressing of sulphate of ammonia applied to half-plots.

TABLE VII

Wheat grain : cwt. per acre
Responses to sulphate of ammonia

	Preceding crop				
	Fallow	Clover	Clover-Ryegrass	Ryegrass	S.E.
1932 (0.2 cwt.) ..	−0.2	+0.7	+1.0	+1.1	±0.835
1936 (0.3 cwt.) ..	+4.6*	+0.2	+1.5*	+1.7*	±0.693
1938 (0.3 cwt.) ..	+1.0	−0.2	+2.1*	+2.5*	±0.693

* = significant response.

As might be expected, sulphate of ammonia gave little if any increase on plots following clover. The plots following the clover-ryegrass mixture and ryegrass alone showed moderate responses in all three years, while the fallow plots have a large response in 1936, a year of high winter rainfall.

In the first experiment, the plots ploughed after the first cut of the leys were left fallow over the summer. In addition to this treatment, the last two experiments contained a comparison of vetches and mustard as green manures grown after the first cut of the leys. The green manures were also grown on some of the plots which had lain fallow since the barley crop. The amounts of nitrogen buried per acre when the green manures were ploughed under are shown below.

TABLE VIII

Green manure crops : nitrogen lb. per acre

		Following				
		Fallow	Clover	Clover-Ryegrass	Ryegrass	Mean
1935	Mustard	12	13	12	11	12
	Vetches	9	13	13	12	12
1937	Mustard	101	71	32	14	54
	Vetches	111	57	32	49	62

The 1935 green manures were practically a failure. In 1937 the stimulation of growth on plots which had previously been fallow is evident, while the clover plots produced a better growth than clover and ryegrass or ryegrass alone. There was little

TABLE IX

Effects of green manures and summer fallow on wheat
Wheat grain cwt. per acre

		Preceding crop					
		Fallow	Clover	Clover-Ryegrass	Rye-grass	S.E.	Mean
1933	Summer fallow	30.4	25.2	21.8	17.8	±0.578	
	2 cuts ..		26.1	19.6	15.1		
1936	Summer fallow	17.6	12.6	13.0	9.8	±0.736	13.2
	2 cuts ..		16.8	15.8	12.4		—
	Mustard ..	15.2	11.2	11.8	12.8		12.8
	Vetches ..	15.3	10.3	9.2	9.0		11.0
1938	Summer fallow	37.0	35.2	29.2	31.6	±0.907	33.2
	2 cuts ..		31.9	29.4	21.9		—
	Mustard ..	34.6	33.6	26.7	23.0		29.5
	Vetches ..	36.8	33.6	27.5	27.8		31.4

difference between the amounts of nitrogen buried in the two green manures.

The effects of taking a second cut of the leys, as compared with a summer fallow, are not very consistent. In 1936 the second cuts produced significant increases in the yield of wheat of about 3 cwt. per acre with all three leys. In the other years the second cuts resulted in significant decreases, except for clover in 1933 and the clover-ryegrass mixture in 1938, for which there was little effect. The growing of a green manure crop generally reduced the yield of wheat as compared with a summer fallow, the average reduction being 1.3 cwt. per acre in 1936 and 2.8 cwt. per acre in 1938. In 1936, when the green manure crops were poor, vetches produced a significantly greater reduction than mustard, but in 1938 the position was reversed.

In each of the three experiments work was undertaken in the Chemistry Department to follow the seasonal changes in the nitrates and ammonia and readily decomposible crop residues of the soils in an attempt to trace the form in which available nitrogen is carried over from one year to another. Samples representing all the treatments were analysed periodically for nitrate and ammonia in the fresh soils and also for the amounts of carbon dioxide, nitrate and ammonia produced during incubation for three weeks under optimal conditions.

In the second and third experiments some of these analyses were also carried out on subsoil samples.

The differences in weather conditions in the three seasons so affected the yield of wheat and the responses to the previous croppings that it is scarcely possible to establish general quantitative relationships between the wheat yields and the simpler nitrogen compounds of the soils, but some general effects emerged.

Fallows caused a high accumulation of nitrate during the summer and a marked reduction in the amount of readily oxidisable organic matter. In the wheat crop of 1932-3 it was possible to establish significant correlations between the mean of values of the soil analyses during the period spring 1932 to spring 1933, and the wheat yields, the yields increasing with the total amount of nitrate and ammonia in the incubated soils and decreasing with the amount of readily oxidisable organic matter (carbon dioxide production). Throughout the winter and spring of 1932-3 soil under wheat had consistently low nitrate contents after each of the treatments and the wheat therefore obtained its nitrogen either from nitrate stored in the subsoil or from crop residues.

In the autumn of 1935 it was possible to follow the temporary accumulation of nitrate in the subsoil down to 27 inches, but in this very wet winter the nitrate throughout the soil to this depth fell to low values. The wheat crop of 1936 was unusually weedy and some of the treatments gave straws which were very rich in nitrogen. Although the wheat yields were not well related to the soil analyses, the total nitrogen contents of the crops as harvested were correlated with the average nitrate contents of the soils to 27 inches during December to March and also positively with the amount of mineralisable nitrogen and negatively with the oxidisable carbon in the surface soil during the early winter.

Under the wheat crop of 1937-8 the soil nitrates during the winter were increased by fallowing, clover, and vetches and decreased by rye grass and mustard in each of three 9 inch depths, but in spring of 1938 they had reached similar values for all treatments at a considerably higher level than in that of 1936.

BARLEY

The production of barley in Great Britain was about 867,000 tons per annum for the period 1927-36; in addition, some 745,000 tons of barley were annually imported.[1] We thus produced about 54 per cent of our total requirements. About 900,000 tons are used for malting, of this quantity about 650,000 tons are used for brewing, about 150,000 tons for distilling, and 100,000 tons for other purposes, and the rest of the barley for seed or for feeding to animals. As the malting barley normally sells at much higher prices farmers are naturally anxious to secure as good samples as possible.

Field experiments on barley have been going on at Rothamsted since 1852 on Hoosfield and at Woburn on Stackyard field since 1876: in both cases barley is grown continuously year after year under the same fertiliser treatment.[2] In 1922 the scope of these experiments was greatly widened by associating the work with the Institute of Brewing, whereby it became possible to ensure proper study of the malting properties of the samples. From time to time Reports on various aspects of the work have been issued and a comprehensive account has now been published by the Director and Dr. Watson.

As is well known, superphosphate produces striking effects on Hoosfield at Rothamsted increasing yield and hastening maturation, but it is not so effective in the ordinary farm rotations where it has already been applied to a previous root crop. If superphosphate is withheld for a few years, however, the yield begins to go down. There is no clear connection between soil type and phosphate effectiveness, and phosphate did not overcome the bad effects of late sowing on the heavy soil of Hoosfield. Superphosphate proved more beneficial after a dry winter than after a wet one, but on the other hand it was more beneficial in a wet April than in a dry one. Its effect was enhanced by adding nitrogenous fertiliser and *vice versa.*

Potassic fertilisers had less effect than phosphates and there was no evidence that their action was improved by nitrogenous fertilisers. The mixture of potassium, sodium and magnesium salts tended to reduce the damage done by a wet winter (being thus unlike the phosphate); it also acted better in a dry summer than in a wet one. It is unfortunately not possible from the Hoosfield experiments to say which of the three elements is the potent one, but other evidence indicates that it is almost certainly the potassium. The withholding of potassic fertiliser has less effect on barley than on wheat, and as both crops contain approximately the same amounts

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[1] The importation has been much higher in the years 1936-38, indeed in 1938 it was 993,000 tons of which about 375,000 tons were used for malting.

[2] Changes were introduced at Woburn in 1926.

of potash, in spite of the shorter growing season of the barley, it seems clear that barley has a greater power than wheat of extracting potash from the soil. Perhaps the most remarkable result of Hoosfield, however, is given by a plot which received farmyard manure every year from 1852 to 1871 and then no manure of any kind ; it still gives nearly double the crop yielded by the adjacent plot which has been without fertiliser since 1852, but there is no certainty that the soils were initially alike.

Farmyard manure is less effective after a wet winter than after a dry one, but there is no evidence that it is specially beneficial in years of dry spring or dry summer.

Fallowing has a remarkable effect on the yield, far greater than is obtained by the use of fertilizer. Experiments in other fields show that undersowing with clover apparently slightly raises the yield, but not significantly.

There is a general relationship between the malting quality of barley and its nitrogen content. High nitrogen content is usually associated with low quality and vice versa, though the rule is not absolute, because the condition of maturation is also important. Of the chemical properties, however, nitrogen content is the most important.

The nitrogen content of the grain is lower on the heavy soil at Rothamsted than on the light soil at Woburn under similar treatment and the variation between different fertilizer treatments is less ; the variation due to season is also less. These relations seem to hold generally. The nitrogen content for different years of the Hoosfield barley is related to the yield ; high yields which are not due to high nitrogenous content of soil or manure are associated with low nitrogen contents and vice versa. The nitrogen is not much if at all affected by fertilizers used in the ordinary way. Where phosphatic or potassic fertilizers increase the yield they may lower the nitrogen content of the grain but not otherwise ; nitrogenous fertilizers may either lower the nitrogen content or they may be without effect. Only if they are used in larger quantities, or if they are unnecessary, do they raise the nitrogen content. Nitrogen content is also related to the sowing date, earlier sowings giving in general lower nitrogen contents than late ones. There is also a marked seasonal effect which is not yet fully understood, but seasonal conditions that increase yield tend to give low nitrogen content. Further, additional rainfall in May, June and July lowers the nitrogen content. These relations are substantially the same at Rothamsted and at Woburn, except that at Woburn the rainfall effect is somewhat more pronounced. The Rothamsted plot receiving farmyard manure, however, stands out as exceptional in that it shows a higher percentage of nitrogen than the others, no effect of rainfall, and no connection between percentage of nitrogen and either yield or sowing date. Thus the effects produced by the rainfall, the date of sowing, and the general yield relations account for some 40 per cent. of the variability in nitrogen content of the grain on the plots receiving artificial fertilizers or even no manure, but for only 16 per cent. on those receiving farmyard manure annually.

The weight of 1,000 corns varies from season to season, but it has not been possible to identify the weather factors responsible for the change. At Woburn rainfall above the average in January, February and March tends to depress the 1,000 corn weight, but no relation can be traced with rainfall in other months nor with temperature after April, nor is there any consistent relation between 1,000 corn weight and nitrogen content.

The bushel weight also varies with the season, but there is no tendency for it to fall even when the yields of the plots are falling. For Hoosfield it has averaged 53 lb. and as the specific gravity of the grain is 1.3 the volume of solid barley in the bushel is 51 per cent. and the volume of air space is 49 per cent.

Conference on Malting Barley

The fifth Conference on the growing of malting barley was held on November 29th, 1938. Samples were sent in by growers from all the important barley growing districts, accompanied by full agricultural details.

The procedure differed somewhat from that of previous years in that growers were requested to send in at least two samples, one of their better, and the others of their poorer quality barley, though still of malting standard. The samples thus represented better than in previous years the whole crop of the grower.

The samples were graded by an expert committee of valuers, and displayed at the Conference to provide the basis of a discussion of the technical problems of barley growing. Six classes were distinguished graded II to VII, there being none up to grade I standard. Grades II and III were pale ale barleys, grades IV to VI mild ale barleys and grade VII feeding quality. The price range between the grades varied from two to four shillings per quarter. Among the 240 samples sent in there were some 65 pairs of samples and of these only 5 of the samples classed by the growers as inferior were given better grading by the valuers. The average difference between the better and the inferior samples was nearly three-quarters of a grade.

This year the lowest malting grade (Grade VI) was assigned about 60 per cent. of the value of the highest (Grade I). In 1937 the relative value had been 75 per cent. and in 1936 and 1935 50 per cent.

Yields were high, but values were low, and the cash returns per acre were about 30 per cent. lower than last year when the crop was a much smaller one.

Sowing conditions were good and nearly all growers reported sowing in February or the first two weeks of March, i.e. about a month earlier than last year. Good growing conditions followed and the harvest weather was good, all conditions being favourable for a heavy crop.

The 201 samples reaching malting standard were divided as follows :—

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TABLE X

District	*Grade* I	II	III	IV	V	VI	Total	Mean Grade
Norfolk			1	3	15	14	33	5.27
Suffolk		1	3	4	9	13	30	5.00
Essex			1	2	3	3	9	4.89
Kent		8	4	3	3	3	21	3.48
Yorks, Lincs and Notts					2	31	33	5.94
E. Midlands . .			1	2	6	11	20	5.35
South			1	1	13	19	34	5.47
West			1	1	7	12	21	5.43
Total		9	12	16	58	106	201	5.19
Percentage . .		4.5	6.0	8.0	28.9	52.7		
1937 Percentage	5.6	15.6	22.9	30.7	19.9	5.2		
1936 Percentage	2.5	2.9	7.6	19.9	46.6	20.6		

So far as the samples sent in were representative of their districts there is a marked effect of locality in the grading results. As last year the Kent barleys were well above the average in quality and those from Essex and Suffolk were better than the average. Those from Norfolk, E. Midlands, West and South, were slightly worse than the average, while as last year the barleys from Yorks and Lincs were well below the average.

The distribution of the grades showed many more samples in the lower grades than in 1936 or 1937.

The estimates of yield for the various districts were :—

TABLE XI

Average yield, bushels per acre

By Districts	
Norfolk	47
Suffolk	43
Essex	47
Kent	55
Yorkshire, Lincs, etc. . .	40
E. Midlands	41
South	39
West	44
1938 Mean	44
1938 Min. of Agric. . .	36
1937 Mean	34
1937 Min. of Agric. . .	28

By Grades (*All Districts*)

	Spring Sown	*Autumn Sown*
II, III	48	47
IV . .	52	46
V . .	44	53
VI . .	41	49
Mean 1938	43	50
Mean 1937	34	33

The mean yields of the samples were, as last year, considerably higher than the Ministry of Agriculture estimates. As before, this was not due to optimistic estimates by the growers since there were 64 samples giving actual (threshed) yields as well as estimated yields and the average difference was over 2 bushels in favour of the actual yield.

Once again Kent, which produced the best samples, also gave the highest mean yield ; the remaining districts were close to the average yield.

The mean yield of the autumn sown barleys was above that of the spring sown, though they showed no marked superiority in quality.

TABLE XII

Grade	*Spring Sown* Number	*Spring Sown* Percentage	*Autumn Sown* Number	*Autumn Sown* Percentage
II, III ..	17	9.7	4	16.0
IV	12	6.8	4	16.0
V	51	29.0	7	28.0
VI	96	54.5	10	40.0
Total ..	176	100.0	25	100.0

The distribution of the grades was very similar for spring and autumn sown barleys with the possible exception that the autumn sown samples had a slightly bigger percentage in grades II, III and IV and somewhat less in grade VI the mean difference being less than half a grade.

The sequence of cropping had but little effect except that after seeds the quality of the barley was somewhat inferior and also the yield was lower.

TABLE XIII

Effect of previous crop on yield and grading

Average yield in bushels per acre

Grade	Corn		Beet or Mangolds		Kale or Turnips		Seeds	
	No.	Average yield	No.	Average yield	No.	Average yield	No.	Average yield
II, III ..	14	51	4	40	1	50	—	—
IV ..	7	56	7	47	1	50	—	—
V ..	22	43	23	47	1	48	5	41
VI ..	48	42	19	42	9	40	13	38
Total ..	91	45	53	45	12	42	18	39

No barleys sown after the middle of March fell into grades II or III. There seemed to be little difference between the quality of barleys sown in February and those sown in the first two weeks of March, with the exception that a few more of the earlier sown barleys fell into grades II and III.

Sowing had been much earlier in 1938 than in 1937, but in spite of that the grading was generally not as good.

TABLE XIV

Time of Spring Sowing

Grade	February	March 1st-14th	March 15th-28th	After March 28th
II, III	11	6	—	—
IV	3	7	2	—
V	24	22	5	—
VI	33	37	22	4
Total 1938 . .	71	72	29	4
Per cent. 1938 . .	40.3	40.9	16.5	2.3
Per cent. 1937 . .	3.2	7.5	16.0	73.2

The manuring of the samples was generally similar to that reported in previous years.

TABLE XV

Manuring

Grade	No Manure	Artificials only	Organic manures	Organic and Artificials
II, III	1	12	2	6
IV	2	5	4	5
V	8	20	10	19
VI	12	48	22	24
Total	23	85	38	54
Per cent. 1938 . .	11.5	42.5	19.0	27.0
Per cent. 1937 . .	8.0	52.0	23.0	17.0

The newer concentrated compound fertilizers had been used for about one third of the 139 samples grown with artificial fertilizers.

For the remaining samples some nitrogen was almost always included in the dressing even when the barley followed sheep or ploughed-in tops : the average dressing was 20 lb. nitrogen per acre, slightly less than the equivalent of 1 cwt. sulphate of ammonia per acre.

In 1938 out of some 240 samples, only 27 cases of lodging were reported, nearly all of them very slight. This was practically the same as last year and only about half of that reported in 1936.

SUGAR BEET

This season 1938 was one of the most unfortunate for beet growers since 1927. Although the year started well with a dry spring and excellent conditions for working the land, the dry weather lasted too long, with the result that germination was irregular and much beet was sown too late. In the Eastern Counties severe summer drought followed with bad attacks of aphis, and really good growing conditions did not set in till late August, when the plant failed to make much use of them.

The effects of manures in this dry and unfavourable season are compared below with their average performance over the previous four years. The main fertilizer effects averaged over all soils are given in Table XVI.

TABLE XVI

		Mean yield per acre of		Increase for					
				Sulphate of ammonia		Super-phosphate		Muriate of potash	
Year	No. of experi-ments	Roots tons	Sugar cwt.	2 cwt.	4 cwt.	3 cwt.	6 cwt.	1¼ cwt.	2½ cwt.
1934-37	94	11.25	39.2	+3.2	+4.6	+1.0	+1.6	+1.2	+1.5
1938	32	8.28	26.7	+1.9	+1.9	+0.9	+1.1	+1.4	+2.9

The yield of roots on the experimental plots in 1938 was nearly three tons below the average of the past four years ; expressed in terms of sugar the difference was 12.5 cwt. Sulphate of ammonia gave much less than its average effect, and on the average the double dose was no more effective than the single application. 2 cwt. of sulphate of ammonia gave 1.3 cwt. sugar less than usual, and 4 cwt. gave 2.7 cwt. less. Superphosphate also was somewhat less effective than usual, but potash was distinctly more effective, the increase of 1.4 cwt. sugar for the single dose of potash and 2.9 cwt. for the double dose was as good as in 1937, which however was a good year for sugar beet. Unlike the other nutrients potash showed no falling off in effectiveness at the higher dressing.

As in previous years nitrogenous and potassic fertilizers each did considerably better in combination with the other than when used alone.

Sugar cwt. per acre

Increase produced by 4 cwt. of sulphate of ammonia

	No potash present	2½ cwt. muriate of potash present
1934-37 ..	+3.8	+5.7
1938 ..	+0.9	+2.0

The increases are smaller than in previous years, but the effects are in the usual direction. In Table XVII the yield effects are summarised by soil groups.

TABLE XVII

Increase in Sugar, cwt. per acre

		Coarse Sands	Fine Sands	Light Loams	Heavy Loams	Clay Loams	Fens
Sulphate of Ammonia							
1934-37	2 cwt.	+3.6	+3.3	+2.6	+2.9	+3.9	−0.2
	4 cwt.	+5.5	+3.1	+4.0	+5.0	+6.8	−0.7
1938	2 cwt.	+3.0	+2.2	+1.0	+1.5	+2.2	−1.3
	4 cwt.	+2.9	+2.8	+1.5	+2.6	+0.5	−2.2
Superphosphate							
1934-37	3 cwt.	+0.6	−0.1	+1.4	+0.6	+1.2	+1.4
	6 cwt.	+1.0	+1.1	+2.1	+1.4	+2.0	+0.6
1938	3 cwt.	+0.9	+1.2	+0.4	+4.8	−0.4	+1.1
	6 cwt.	+0.3	+2.0	+0.8	+6.2	+0.5	+0.9
Muriate of potash							
1934-37	1¼ cwt. ..	+1.8	+2.0	+0.8	+1.6	+0.2	+1.2
	2½ cwt. ..	+1.7	+2.0	+1.4	+0.4	+0.2	+2.2
1938	1¼ cwt. ..	+2.6	+0.4	+0.6	+0.6	+1.8	+1.6
	2½ cwt. ..	+3.8	+1.8	+2.0	+0.9	+4.3	+3.6

Nitrogen was less effective than usual in all soil groups, indeed in the fens its effect was if anything depressing. Superphosphate did better than usual on the fine sands and heavy loam, but the latter value was based on only one centre in 1938. The marked effect of muriate of potash appeared in this season in three soil groups, coarse sands, fens, and clay loams, although the good results in the last group were largely due to one particularly responsive centre on a gravelly clay. The weights of tops are given in Table XVIII.

TABLE XVIII

Tops, tons per acre

Year	No. of experiments	Mean Yield	Increase for sulphate of ammonia	
			2 cwt.	4 cwt.
1934-37	73	9.2	+1.4	+3.0
1938	28	9.6	+1.5	+2.8

Although the yield of roots was low in 1938 the average production of tops was normal. Nitrogen had the biggest effect on tops, the yields and increases being close to the four year average : the increase produced by the double dressing was as usual almost twice that produced by the single dressing.

The sugar content of the roots was little affected by phosphate, somewhat lowered by nitrogen and slightly increased by potash, as in previous years (Table XIX).

TABLE XIX

Sugar in roots, per cent.

Year	Mean	Increase (+) or decrease (−) for			
		Sulphate of ammonia		Muriate of potash	
		2 cwt.	4 cwt.	1¼ cwt.	2½ cwt.
1934-37 ..	17.4	−0.15	−0.38	+0.15	+0.22
1938	16.2	−0.1	−0.4	+0.2	+0.3

The sugar percentage in 1938 was exceptionally low, no less than 1.2 per cent. below the average of the past four years.

The poor seed bed conditions were reflected in a plant number somewhat lower than usual, on the clay loams the population was only 18.8 thousands. Fertilizers had but little effect except that potash significantly increased plant number at four of the thirty-two centres.

TABLE XX

Plants. Thousands per acre

Year	Mean	Increase (+) or decrease (−) due to :—					
		Sulphate of Ammonia		Superphosphate		Muriate of Potash	
		2 cwt.	4 cwt.	3 cwt.	6 cwt.	1¼ cwt.	2½ cwt.
1934-37 ..	27.8	+0.28	+0.25	+0.28	+0.25	+0.22	+0.32
1938 ..	26.1	0.0	−0.2	+0.2	+0.1	+0.2	+0.4

ORGANIC MANURES

The importance of maintaining the supply of organic matter in the soil is well recognised, but nothing is gained by the exaggerated claims sometimes put forward on the subject.

The standard organic manure, and the one which would suffice for all needs if it were available in sufficient quantity, is farmyard manure. Unfortunately the shrinking acreage of straw crops, and the reduction in number of yard-fed cattle have reduced the amounts of farmyard manure available and substitutes have to be found.

A very tempting source of organic manure is furnished by some of the waste materials of the towns, which at present are not fully utilised or even are only a source of embarrassment. Chief of these is town refuse which is available in enormous quantities and which along with much useless material contains substances of undoubted fertilizer value. In its crude form it is not readily taken by farmers and large amounts have annually to be dumped either in the sea or in the country where a complaisant land-owner or council will give the necessary permission.

Town Refuse.—The older Rothamsted experiments on town refuse indicated that the sorted and pulverised materials from Hampstead and from Walworth had fertilizing value, and they were at least as effective as dung in the one experiment in which the comparison was made.

1923 Mangolds, *tons per acre*	
No manure	**9.6**
15 tons dung	**13.2**
15 tons Hampstead refuse	**14.0**
15 tons Walworth refuse	**13.9**

1924 Oats, *bushels per acre*	
No refuse	**31.1**
5 tons	**35.4**
10 tons	**36.8**

No great certainty attached to these results, since standard errors could not be calculated; all the same the 1938 results suggest that they were probably not far wrong.

In 1938 a prepared town refuse was compared with (1) sulphate of ammonia and (2) dung or rape dust, each given in single and double dressing, the nitrogen content being taken as the basis for comparison. The sulphate of ammonia dressing provided only one half of the nitrogen of the corresponding organic manure. At Rothamsted and Woburn dung was the organic manure chosen; at the outside centres it was rape dust. The town refuse varied somewhat in composition and was applied on the basis of its analysis; its mean composition as used was N=0.82 per cent; moisture=30.3 per cent.

The rates of application were :—

Single dressing of Town Refuse (about 5 tons per acre), Rape Cake, Dung 0.8 cwt. N. per acre.

Single dressing of Sulphate of Ammonia 0.4 cwt. N. per acre.

The double dressings were at twice the above rates. Town refuse significantly increased the yield of kale at Rothamsted, sugar per acre at Woburn, and of potatoes at Tunstall. It increased the number of " bolters " in the sugar beet at Woburn, and the percentage of diseased potatoes at Tunstall. It gave higher yields than farmyard manure providing equal nitrogen in three out of four comparisons at Rothamsted and at Woburn, and in one of these comparisons, the double dose of refuse against the double dose of dung at Woburn, the difference was statistically significant. Table XXI gives the yields and Table XXII shows whether the refuse did better or worse than sulphate of ammonia providing one quarter, one half, or the whole of the nitrogen.

TABLE XXI

Comparison of treated town refuse with other nitrogenous manures

		Increase over no nitrogen								
		Single Dressing				Double Dressing				
	Mean Yield	Sulph. amm.	Town refuse	Dung	Rape dust	Sulph. amm.	Town refuse	Dung	Rape dust	S.E.
N. cwt. per acre		0.4	0.8	0.8	0.8	0.8	1.6	1.6	1.6	
Rothamsted: Kale tons per acre ..	10.39	+1.21	+1.49	+0.97		+2.81	+2.80	+1.39		±0.465
Woburn: Sugar beet Total sugar: cwt. per acre	34.5	+6.3	+4.8	+5.8		+7.2	+7.5	+4.4		±1.71
Tops: tons per acre	7.85	+2.30	+1.02	+1.36		+4.76	+3.20	+1.23		±0.398
Plant No. thous. per acre	35.0	−1.2	−1.6	−0.4		−1.8	−2.4	−1.2		
Bolters percentage ..	3.95	+0.02	+2.62	−0.51		+2.42	+3.26	+1.52		±0.984
Rochester: Mangolds Roots: tons per acre	24.30	+0.95	+0.78		+4.92	+7.33	+2.13		+5.25	±1.63
Plant No.: thous. per acre	24.6	+0.6	+0.7		+2.5	−0.3	+0.5		+2.9	±0.826
Siddlesham: Potatoes Total produce: tons per acre	10.01	+0.89	−0.44		+1.98	+2.18	+1.61		+1.02	±0.960
Percentage ware ..	90.8	−0.3	−0.6		+1.5	+0.7	+1.1		−2.1	±1.63
Tunstall: Potatoes Total produce: tons per acre	11.39	+2.08	+1.09		+2.66	+3.18	+1.08		+4.44	±0.433
Percentage ware ..	88.6	+1.3	+0.4		+2.9	+3.2	+1.5		+5.8	±0.933
Percentage diseased ware	7.8	−0.3	+0.3		+4.7	+4.7	+2.8		+5.8	±1.201

TABLE XXII

Comparison of treated town refuse with sulphate of ammonia
Town refuse superior (+) or inferior (−)

		When sulphate of ammonia provides nitrogen:		
Nitrogen in refuse	Crop	Equal to the N. of refuse	½ the N. of refuse	¼ the N. of refuse
0.8 cwt. per acre	Kale	—*	+	
	Beet	—	—	
	Potatoes (1)	—*	—	
	Potatoes (2)	—*	—	
	Mangolds	—*	—	
1.6 cwt. per acre	Kale		—	+*
	Beet		+	+
	Potatoes (1)		—	+
	Potatoes (2)		—*	—
	Mangolds		—*	+

(1) Siddlesham. (2) Tunstall.

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* Difference between refuse and sulphate of ammonia statistically significant.

Treated town refuse did almost as well as sulphate of ammonia providing half as much nitrogen, and was distinctly superior to sulphate of ammonia providing one quarter of the nitrogen, though it was much inferior to sulphate of ammonia supplying the same amount of nitrogen.

These estimates are derived only from the yields in the year of application, and it is possible that the refuse might build up residual effects if used in heavy dressings. Further experiments should be instituted to test residual and cumulative effects. The similarity in effectiveness to dung emphasises the desirability of adequately investigating the possibility of utilising town refuse in agriculture.

There is also some hope that another waste product, now a source of embarrassment to the towns, may become of value to farmers. Much of the sewage sludge at present made is of so little value that farmers wisely do not buy it. There is, however, at least one type of sludge that would have considerable fertilizer value if it could be dried and powdered for distribution. Hitherto no suitable method has been available, and instead the sludge has been destroyed by digestion. We understand that there is now the possibility that this difficult drying problem may be solved.

The experiments with dried poultry manure were also continued ; in these the nitrogen had about two-thirds the value of that of nitrogen in sulphate of ammonia.

The fertilizer value of all these organic waste substances is determined by the nature of their carbon and nitrogen compounds and by the ratio of the carbon to the nitrogen. The work of the Fermentation Department consists in finding out exactly what part these various factors play so that the probable fertilizer value of any particular waste material may be forecasted from analysis and, more important, improvements in fertilizer value may be suggested.

USE OF STRAW AS MANURE

On July 15th, 1938, an informal conference of farmers and technical experts was held at Rothamsted on the use of Straw as a Soil Improver. Most speakers had observed that the ploughing in of raw straw had a depressing effect on the crop immediately following. The most favourable result was that the straw used in this manner did no harm. The bad effect was probably mitigated if the straw was ploughed in when the land was still warm, i.e. immediately after harvest, so that some decomposition could take place before winter. If a bare fallow followed straw ploughed in, most of the straw disappeared during the course of the fallowing operations.

In practice some form of nitrogen was usually added to straw. This was done either by direct additions of calcium cyanamide or sulphate of ammonia to the straw before turning under, or alternatively by giving a nitrogenous dressing to the following cereal crop. The rate of application was approximately 1 cwt. of nitrogenous manure per ton of straw.

No one advocated the burning of straw on the land ; ploughing under with the addition of cyanamide was said to have given noticeably better results.

It is possible to assist the decomposition of straw by growing red clover under the corn crop and turning it in with the cereal straw.

Composting the straw in heaps with the addition of cyanamide or dung had been tried, but succeeded only when a water supply was available.

Another use of straw was for the improvement of glass house soils that had lost their texture through surface watering, but were richly supplied with dung and artificials. Walls of straw let vertically into the soil improved aeration, drainage, and root action.

One complication of special importance to mechanical cereal growers is the incidence of Take-all Disease (*Ophiobolus graminis*). The fungus survives in the stubble, and control methods centre round the hastening of decomposition of the fungus after the stubble has been ploughed under. Carbohydrate additions facilitate the decomposition of the fungus, but additions of nitrogenous fertilizers tend to protect it. Furthermore although straw provides carbohydrate it also tends to aerate the soil, and aeration, while facilitating the decomposition of the fungus in the autumn and winter, assists in spreading it when the following crop has been sown. When Take-all is prevalent the stubble should be ploughed at the earliest possible opportunity together with additional straw if available. No nitrogen should be given and ploughing should be shallow to facilitate aeration which at this stage is beneficial. In the following spring the seed bed should be heavily rolled to restrict aeration and nitrogen may then be applied to the crop that follows.

GREEN MANURE

Another possible source of organic manure is to grow and plough in a green crop.

The effects of mustard, tares and lupins as green manures preceding kale were studied in a number of experiments at Woburn. In 1934, lupins were grown on all plots, the treatments compared being : removing the whole plant ; removing the tops and burying the roots ; burying the whole plant ; and burying the whole plant and extra tops. The lupins were followed by two years of kale.

Woburn : Kale (tons per acre)

	Yield with whole plants removed	Increase in yield with			S.E. of increase
		Roots buried	Whole plants buried	Whole plants and extra tops buried	
1934	3.54	−0.38	+3.15	+4.93	±0.287
1935	4.01	−0.07	+1.06	+2.16	±0.489
Nitrogen buried in 1934 (lb. per acre) ..	0	11	133	256	

The burial of the roots produced no beneficial effect on the yields of kale. There were substantial responses in 1934 where the whole plants were buried, the response per 10 lb. of nitrogen buried being about 0.3 tons with the single dressing of tops and somewhat less with the double dressing. The residual effects in 1935 were similar, except that the double dressing was as effective per unit of nitrogen as the single dressing.

The experiment was extended in 1935, the green manures being mustard, tares and lupins ; there were also some plots which lay fallow preceding kale. As the 1935 kale crop was eaten by pigeons the green manures were grown again in 1936 ; the yield of kale then was :—

TABLE XXIII

Woburn : Kale (tons per acre), 1936

Crop	Yield after fallow	Increase in yield after green manure				S.E. of increase
		Whole plant removed	Roots buried	Whole plant buried	Whole plant and extra tops buried	
Mustard	6.62	−1.12	−1.68	−0.70	+0.79	±0.538
Lupins		+0.13	−0.18	+2.40	+3.61	
Tares		+0.53	+0.54	+3.66	+6.20	
		Nitrogen buried (lb. per acre)				
Mustard		0	2	37	66	
Lupins		0	6	41	77	
Tares		0	6	53	106	

With whole plants or tops removed, the growing of a green manure crop of mustard reduced the yield of kale significantly by over a ton per acre, while lupins and tares had little effect. Burial of the tops increased the yields significantly with lupins and tares. The increases to the double dressings per 10 lb. nitrogen buried were 0.39 tons for mustard, 0.53 tons for lupins and 0.57 tons for tares, the last two being significantly greater than the first. Even with the addition of extra tops, however, mustard proved little if at all better than fallow, though lupins and tares were markedly better than fallow.

The experiment was continued on the same site in 1937, but the kale was badly eaten by birds. Notwithstanding this, the buried tops of lupins gave substantial increases over fallow. In 1938, on a different site, the tares crop failed. The results for lupins and mustard were similar to those described above.

Woburn : Kale (tons per acre), 1938

Crop	Yield after fallow	Increase in yield after green manure			
		Whole plant removed	Roots buried	Whole plant buried	Whole plant and extra tops buried
Mustard	9.04	−1.86	−2.42	−1.54	−0.48
Lupins		−0.36	+0.60	+1.13	— *

*Plots severely affected by a snowstorm.

A comparison of the manurial values of buried tares and mustard is made each year in the Woburn green manuring experiment on Stackyard, started in 1936. The 1937 and 1938 yields of kale were exceedingly poor and showed no significant effects of the green manures. The 1936 results were :—

Woburn (Stackyard) Kale : tons per acre, 1936
Green Manure

None	Mustard	Tares
12.52	12.62	13.90

Mustard was again ineffective, but tares gave a significant increase of 1.4 tons per acre. The kale crop was followed by barley, which gave a significant residual response to tares of 2.2 cwt. per acre.

THE SOIL

One of the oldest problems in agricultural chemistry is to attempt a forecast of the effects of fertilizers on crops, this being done on the basis of chemical analysis. It was at one time thought that the problem was quite simple, and that a chemical analysis of the soil would readily show its response to fertilizers. Actual trial has proved that this view is wrong ; no method of analysis yet tested accurately forecasts the effects of fertilizers : the soil is too complex to allow the problem to be solved in an easy way. Fortunately the liming problem is less difficult. Various methods are in use for estimating chemically how much lime is needed, and one of the most popular was devised at Rothamsted, but results are by no means clear cut and much further investigation is needed before they can be regarded as satisfactory.

The whole subject is under investigation in the Chemical Department.

The field experiments furnish numerous samples of soils which vary in their responses to potassic and phosphatic fertilizers, and these soils are examined chemically to find out how their composition is related to the fertilizer results.

Certain rapid methods for approximate analysis of soil have been examined and their possibilities noted, and a rapid pot culture method of soil analysis is also being studied in the hope of evolving something that will combine the advantages of the Neubauer and the Mitscherlich methods with certain other advantages. Now that the new chemical wing is built it is hoped to set up a spectrograph which would, of course, greatly facilitate the whole of this work and make possible rapid surveys that might prove of the utmost value.

Phosphorus compounds in soil.—The phosphorus compounds of the soil have also been studied in the Chemical Department. This subject is of particular importance at the present time because our field experiments indicate that, of the phosphate added as fertilizer, only about 25 per cent. is recovered in the crop in ordinary circumstances : the rest remains in the soil, but it is, so far as we can discover, in a form in which plants cannot easily take it up. On our present evidence the soil is a poor store house for fertilizers.

In the Rothamsted soils much of the phosphorus is present as iron phosphate even in neutral soils and those heavily dunged. Fenland soils are remarkable in their phosphate relationships and these are being studied in detail. A large part of their phosphate seems to be there in combination with iron and aluminium. The organic phosphorus compounds in soil appear to be relatively inert.

Manganese deficiencies in soils.—Three main types of soil are liable to manganese deficiency as shown by characteristic crop troubles.

(1) Neutral or alkaline soils, notably recently limed reclaimed heath soils, which do not contain manganese minerals. These are liable to " Grey Speck " of oats.

(2) Alkaline fen soils : these are liable to " Speckled Yellows " of sugar beet.

(3) Heavily alkaline marsh soils, even if they contain manganese minerals : these are liable to " Marsh Spot " in seed peas.

All three diseases have been remedied by suitable applications of manganese sulphate. It should be noted that they can all be brought on by over-liming, and it is not difficult for a farmer to injure his crops by putting on more lime than the crop really needs.

Cobalt deficiencies in soils.—Both in Australia and in New Zealand animals grazing on certain pastures have suffered from a disease traced to cobalt deficiency. In the Chemical Department it has been shown that pastures in the Dartmoor area are also deficient in cobalt ; the sheep there suffer from a disease similar to that in New Zealand. The remedy is to give a cobalt lick, but it is clearly desirable to make a survey of other hill or moorland grazings.

Soil Minerals.—Farmers recognise many different types of soil, and soil surveyors make maps showing their distribution in particular areas. But in order to understand them properly it is necessary to find out exactly how they differ, and investigations both of the organic and of the inorganic constituents have long been in hand. X-ray analysis is now used in the Chemical Department for the identification of the minerals in the various soil fractions and examinations made this year have included soils from India (in collaboration with Dr. A. Muir and A. D. Desai of the Macaulay Institute), from the United States Bureau of Chemistry, from Malaya and from the Malvern Hills. Special attention has been devoted to the clay fraction as being one of the most characteristic and at the same time most difficult to investigate. It is being studied in the Chemical Department by X-ray methods, and in the Physics Department by other physico-chemical and physical methods. Each set of methods reveals something about its constitution. The clay fraction is not homogeneous, but its special properties are largely due to certain components now under investigation. They are very complex, and their smallest particles are shown by X-ray analysis to consist of a lattice structure in which layers of silicon and oxygen atoms alternate sandwich-like with layers of aluminium and oxygen atoms arranged systematically. The particles are electrically charged and hence have associated with them various ions, of which the most important from the point of view of soil fertility are calcium, and in our conditions, hydrogen and potassium, but in arid conditions sodium and magnesium. These cations are replaceable by others : the " souring " of soil is caused by the replacement of calcium by hydrogen ; conversely the " sweetening " of the soil by liming is due to the replacement of hydrogen by calcium. The electric charges appear to originate in three ways. Some are due to isomorphous replacements within the crystal lattice and are permanent in the sense that they are not influenced by the hydrogen ion concentration of the medium in which the clay is suspended, although this determines whether they are balanced by H+ ions or metallic cations. The other two kinds of electrical charges are associated with the surface of the clay particles when suspended in a solution of an electrolyte. One is associated with acidic " spots " where negative charges develop at high pH values of the medium through dissociation of the H+ ions which probably come from hydroxyl groups attached to silicon atoms at the corners and edges of the crystals. The other of these two kinds of charges is associated with basic " spots " which become positively charged at low pH values of the medium through combination with H+ ions : the chemistry of this process is not known, but it may involve an interaction with an aluminium-oxygen group. These basic " spots " occur on many of the common subsoil clays and indeed in some instances, a striking example of which was a red clay from Natal, they are so numerous that they exceed the permanent negative charges. In such cases by regulating the degree of acidity the number of positive charges can be made equal to the number of negative charges and the clay then carries no nett charge : it becomes incapable of retaining exchangeable ions, e.g. it cannot, like a fertile clay, hold calcium, magnesium and potassium and supply them to the growing plants.

The recognition of clays that can thus become uncharged at only a moderate degree ot acidity (pH 5) is obviously of considerable agricultural importance. The defect can to some extent be remedied by the addition of humic material which at this pH is negatively charged, and in such soils it is essential to maintain the supplies of organic matter.

These basic spots do not occur on all clays : montmorillonite and kaolinite seem to be free from them.

Soil surveyors use the colour of the soil as one of its properties for classification, but the estimation of soil colours is very vague. Dr. Schofield has devised an instrument for exactly measuring colour, and this has been taken over by Tintometer Ltd. for exploitation on a commercial scale. The instrument should prove of great value to a wide range of workers.

Water supply to plants.—The water supply to plants is at least as important as the food supply, and it is well known that different soils show remarkably wide variations in their power of holding water : some retain a large part so firmly that plants cannot get it, others hold the water with much less tenacity. A method of measuring the intensity with which soils hold water has been worked out in the Physics Department and is being developed for wider use. The underlying conception of water suction is being applied to a study of the pore size distribution in soils.

CROPS AND MICRO-ORGANISMS

For many years the Bacteriology Department has been engaged on a study of the organisms associated with leguminous plants and one of the best known results has been the working out of a method of inoculating lucerne seed before sowing : this is now generally adopted by farmers.

Investigation showed that clover nodule bacteria are very widely distributed throughout the country, but that some of their strains or varieties are much less efficient than others. One of the poorest, found on the Welsh hills, has been studied in some detail.

It is so inefficient that it can barely sustain its host plant ; the growth of the clover is miserably poor. The reason for the inefficiency of such strains has now been traced to some incompatibility between them and their hosts : they get into the root and start forming the nodule, and then commence to fix nitrogen just as the more efficient forms do. But in a very short time the nodules begin to disintegrate. Similar results have been obtained with peas and soya beans. Evidence was obtained that plants bearing inefficient nodules produce some substance toxic to the organisms and so put an end to their activities. There is acute competition between good and poor strains of nodule bacteria in the soil, and apparently those that multiply most rapidly are able to dominate the others and to enter the plant.

Soil contains quantities of unspecialised bacteria which have hitherto been little studied but are important by reason of their large numbers and variety. A survey to study their distribution under different systems of cropping and manuring is being made in the Microbiological Department. There is some suggestion of a relation between cropping and bacterial flora : comparison of the unmanured plots on Broadbalk wheat field and on Park Grass showed only two species of bacteria common to both, but on the other hand four of the eleven species isolated from the unmanured Park Grass plot were found on unmanured grassland in other parts of the country.

The process of denitrification whereby nitrates are reduced in the soil to gaseous nitrogen has hitherto been regarded as entirely anaerobic. It is now shown that this is not so, and that complete reduction of nitrate to gaseous nitrogen can take place under aerobic conditions with the difference that, for a C/N ratio of 10, the whole of the carbon supplied is used up under aerobic conditions, but part of it is left untouched under anaerobic conditions.

Light appears to have no effect on the process.

It is a commonplace that scientific investigations properly carried out are apt to develop in wholly unexpected directions. This work on soil organisms was soon found to provide the key to a particularly difficult practical problem, the purification of effluents from sugar beet factories and from milk factories. By arrangement with the Department of Scientific and Industrial Research this problem was actively followed up for several years, with such success that at the end of September 1938 it had reached the stage where it passed out of our hands and could be handed over to the factories as a matter of factory technique. The work was done jointly by the Microbiological and Fermentation Departments with the cordial co-operation of Anglo-Scottish Sugar Beet Corporation (Colwick) and United Dairies Ltd. (Ellesmere).

Soil fungi responsible for certain plant diseases are dealt with later, where it is shown that the persistence of one of the more serious diseases is related to the bacterial activity in the soil.

The protozoa of the soil have also been studied and it is shown that, in addition to their effect in reducing bacterial numbers, they have a further effect in raising the bacterial efficiency, as the members of a small bacterial population are more efficient than those of a large one.

INSECT PESTS OF CROPS

In the Entomology Department the staff investigate the factors governing the rise and fall of insect populations. For some years past the relation between weather conditions and population numbers as sampled by a light trap has been studied and the special feature of the work has been the use of statistical methods of analysis to ensure that the maximum of information is obtained from the results and that no unwarranted conclusions should be drawn. Important results are already foreshadowed. For the insects studied the population level at any time is determined by the conditions prevailing during the previous weeks or months, and multiple regressions have been worked out from which the populations should be predictable with fair approximation at least one month beforehand. The principal factors concerned are temperature and rainfall, the former being more important in winter and the latter in summer. The rainfall of two months previous has a greater effect per inch of rain than that of either one month or three months previous.

Population changes in the field have also been studied in carrot fly, leather jackets and gall midges, and in these the effect of parasitism is taken into consideration.

Other work on gall midges has also been continued.

A new line of work has been opened up which promises to be particularly important when it can be developed in association with a biochemist ; at present no successor has been appointed to Dr. A. G. Norman and in consequence the station is without expert guidance on the subject. Investigations of cabbage aphis show that the rate of reproduction of the aphides is dependent on the composition of the cabbage, and that the aphides themselves affect not only the yield but also the composition of the cabbage. These reciprocal relationships promise to be important and they will be worked up as opportunity arises.

Considerable attention is devoted to soil insects, especially those that live in grassland and may become serious pests when the grass is replaced by arable crops.

Dr. Williams' work on Insect Migration has been considerably strengthened by the receipt of a grant from the Leverhulme Foundation which has much facilitated the recording and study of observations. Those dealing with migrations of Cabbage White Butterflies in Europe were worked up during 1938 ; other material is accumulating.

INSECTICIDES AND FUNGICIDES

During 1938 this work has been greatly extended under a scheme sponsored by the Agricultural Research Council and the Colonial Development Fund and additional chemical and entomological assistance has been provided. It has now become possible to carry out biological tests throughout the greater part of the year, and still further progress may be expected as the selection of more suitable test insects proceeds. Under the conditions of the grant special attention is to be devoted to the insecticidal plants grown in Malaya.

The chief work has been on Derris, and it has been concerned with a critical examination of the methods of determining rotenone, the substance on the basis of which derris is usually standardised. This was done in close consultation with the Imperial Institute and satisfactory progress has been made. Some of the other active principles are being examined as regards both their chemical constitution and their insecticidal activity.

Certain Australian plants used as fish poisons by the aborigines have also been examined as insecticides, and one of them, a species of *Tephrosia*, was toxic to *Aphis rumicis*, but not to the same extent as Derris or certain species of Lonchocarpus.

The effect of manuring on the yield of pyrethrum flowers, and on their pyrethrin content, has now been fairly well ascertained.

VIRUS DISEASES

Considerable advance in this subject was made in 1938. In collaboration with Mr. N. W. Pirie ot the Biochemical Laboratory, Cambridge, work has been continued on the isolation of plant viruses. From plants infected with two strains of potato virus " X," nucleo-proteins have been isolated which in many ways resemble those previously obtained from plants infected with tobacco mosaic type viruses. In dilute solutions these show the phenomenon of anisotropy of flow and when sufficiently concentrated they form liquid crystalline solutions. When precipitated from solutions with acid or with salts these proteins are amorphous. From plants infected with tomato bushy stunt virus another nucleo-protein has been isolated, which after precipitation with salts crystallises in the form of rhombic dodecahedra. This is the first virus which has been obtained in a fully crystalline state. It differs from those previously studied in having spherical instead of rod-shaped particles, also in having a much greater nucleic acid content. Nothing like these proteins has been isolated from virus-free plants, although tobacco and tomato plants have been found to contain relatively large amounts of proteins with large molecular weights. The conditions in which these nucleo-proteins break down have been studied but none of the evidence conflicts with the view that they are the viruses themselves.

On the cytological side an approximate estimate of the virus content of the abnormal " inclusions " found in cells of leaves affected by Aucuba mosaic disease showed that its activity is of the same order as that of an equal weight of purified virus.

Further studies were made of the relations between the insect transmitted viruses and the insects that carry them, particularly the effects of fasting and times of feeding.

FUNGUS DISEASES OF CROPS

" Take-all " disease (*Ophiobolus graminis*) continues to cause trouble in wheat growing areas and it is shown that the fragments of mycelium persisting in the soil are the most important source of infection. The fungus produces air-borne ascospores, but these are apparently incapable of initiating outbreaks of disease in the field.

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The chief factor in the persistence of the disease in a particular field is therefore the length of time that the mycelium can continue to survive in the soil. Fortunately the mycelium does not live indefinitely: it is attacked and decomposed by other soil organisms. The most favourable conditions for this appear to be (1) high microbiological activity in the soil; (2) maximum soil aeration; (3) temporary scarcity of nitrogen, which drives the soil organisms to attack the *Ophiobolus* mycelium for the sake of its nitrogen. Co-operative experiments have been started with the Norfolk Agricultural Station to apply these results to farm practice.

Fortunately the English variety of the fungus does not attack oats and in consequence oats can be sown on infested land in Eastern and Southern England. Grasses also are not affected.

In Wales, however, it is different. Another strain or perhaps even another species of the fungus has been found there which attacks both oats and grasses, thus differing widely from the English strain. One hopes it will not invade Eastern or Southern England.

The fungus *Fusarium culmorum*, which causes trouble to wheat growers has also been studied: it can colonise dead plant remains, and was indeed the dominant fungus, with *Mucor spp.* as sub-dominant, in decomposing wheat stubble for at least the first three months after it had been ploughed into the land. Later on these were replaced by *Penicillium spp.* as dominants. Enrichment of the straw with nitrogen accelerated the decomposition but did not alter the succession of fungi. The practical significance of the results lies in the fact that *F. culmorum* must now be considered a regular member of the fungus flora of the soil, since it can colonise dead plant remains, and is therefore not restricted to a parasitic life. It is, therefore, highly improbable that any system of crop rotation will eliminate this wheat parasite from the soil, so that control measures must rather be directed towards raising by appropriate cultural measures the resistance of the cereal host plant to disease.

The fungus *Cercosporella herpotrichoides*, which causes lodging in wheat, was first found in this country by Miss M. D. Glynne at Rothamsted in 1935. It was afterwards recognised in a number of places on wheat in the southern half of England, and occasionally on winter barley, and it was much commoner in the wet season of 1937 than in the drier season 1938 when there was much less lodging and the percentage of infection was lower.

The effects of the fungus are more marked when wheat has closely to follow wheat or barley than when a wider interval is possible.

STATISTICAL CONTROL OF THE EXPERIMENTS

Design of Field Experiments and Analysis of the results

It is obviously useless to make field experiments unless the results are reliable, and long experience has shown that the old simple designs frequently give untrustworthy results; moreover no estimate of their validity can be made. In the Statistical Department new methods have been developed which enable the experimental errors to be properly assessed and which are far more efficient than the older methods. The new methods are now widely used in the Empire, especially in India, Ceylon, Malaya, Australia, the Sudan, and in many parts of Canada and Great Britain as well as in the United States. They are continuously being improved, and during 1938 quasifactorial and incomplete block designs were studied: these are already much used in plant breeding work, in experiments on virus disease and other problems. Designs for rotation and other long term experiments are also being investigated, and numerous experiments of this type involving many novel features have been commenced at Rothamsted and Woburn.

When the experiments are done the results have to be analysed and relations with meteorological and other data investigated. The results of the Saxmundham experiments are being worked out on these lines. Methods of dealing with survey data have been developed, and used in an enquiry into potato blackening carried out for the Potato Marketing Board in conjunction with the Imperial College Botany Department.

The Statistical Department also does a good deal of work in association with other bodies: during 1938 it carried out an investigation for the Forestry Commission on methods of sampling for yield of timber.

Special attention is given to the study of methods of crop forecasting: this is done in association with the Plant Physiologist. The particular crops at present under investigation are wheat, potatoes, and sugar beet.

FIELD EXPERIMENTS AT OUTSIDE CENTRES, 1922-38

When the wheat experiments on Broadbalk field had been carried on for eight years, Lawes repeated certain of them on lighter soil at Holkham, Norfolk (¹) for four successive years, the manures being made up at Rothamsted. Five years later some Kentish farmers who had visited Rothamsted were so interested in the wheat field that they offered to repeat the experiment in their own area: this they did for six years at a centre near Sittingbourne. Writing of these experiments (²) Lawes and Gilbert say: "It is highly desirable, in a practical as well as a scientific point of view, to determine, by means of careful experiments, whether or not the action of particular manures on particular crops is substantially similar on different descriptions of soil and in different localities."

Although the need was clearly appreciated the early records show few excursions to outside farms apart from the above. In 1876 the Woburn experiments began and the main treatments of Broadbalk and Hoosfield were repeated on a light soil and maintained for 50 years. (³)

Until after the War the small size of the staff had not allowed of any but occasional experiments outside of Rothamsted; this became possible as soon as the staff was enlarged. There were, however, certain administrative difficulties as the scheme under which research institutes then worked did not envisage investigations outside the institutes, except at the request of the local authorities.

(¹) J. B. Lawes. Jour. Roy. Agric. Soc. Eng., 1855; *16*; p. 207.

(²) J. B. Lawes and J. H. Gilbert. Jour. Roy Agric. Soc. Eng., 1862; *23*; p. 31.

(³) E. J. Russell and J. A. Voelcker. Fifty years of field experiments at Woburn Experimental Station. Rothamsted Monographs Agric. Sci., 1936.

These difficulties were gradually overcome, and in 1921 a serious start was made with field experiments on commercial farms in connection with problems arising out of certain reorganisations of the fertiliser industry which were then proceeding. In 1922 the work was extended: experiments were begun under the aegis of the Institute of Brewing to test the effects of fertilisers on the yield and quality of barley grown on a number of good barley growing farms in many parts of the country. The results were published periodically in the Institute's Journal, (4) and finally summarised. (5) The station also became associated with the Leadon Court Farm of Sir E. D. Simon where a large scale trial was made of the use of arable crops for dairy farming. Other experiments dealt with the possibility of using muriates(6) and silicates as fertiliser. The work had now so much increased that T. Eden was appointed to supervise the experiments.

Gradually the organisation of these outside experiments was developed. They were usually repetitions of experiments at Rothamsted, and the plans were sent out to co-operators at agricultural colleges, and the results were worked up at Rothamsted and circulated to all concerned.

In 1924 the Royal Agricultural Society of England gave a grant for experiments on green manuring at outside centres(7). These were much more difficult to carry out than the manurial experiments since they involved the successful establishment of the green manuring crop as well as the crop whose yield was measured. In the meantime grazing experiments evaluating in terms of live weight increase the effects of different types of basic slag on grass land had been conducted at Rothamsted for some years and these were extended to the outside centres (8) in 1925. This type of work involved much closer supervision than anything previously and this was secured by enlisting the help of local workers.

The above experiments were carried out on the then accepted technique of single large plots, or sometimes duplicated or triplicated; but by 1926 the improved plot arrangements developed by R. A. Fisher had proved so advantageous at Rothamsted that they were adopted on commercial farms at the outside centres; H. J. G. Hines being in charge (9); and henceforward the field results were published yearly in the Station Report in the same form as the Rothamsted experiments. Two sections are maintained; the first containing experiments carried out entirely by the Rothamsted staff; the second comprising experiments designed and statistically analysed at Rothamsted, but conducted in the field by local workers with little or no assistance from the Station. In 1928 a scheme was begun whereby certain schools possessing the necessary land were

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(4) E. J. Russell. Jour. Inst. Brew., 1923; *29*; p. 624; and subsequent volumes.

(5) E. J. Russell and L. R. Bishop. Ibid., 1933; *39*; p. 287.

(6) Min. Agric. Bull 28. 2nd Edn., 1932. pp. 62, 80, 81.

(7) H. J. Page. Rothamsted Conferences, 1927. No. 3, p. 13.

(8) Rothamsted Station Report, 1925, p.24.

(9) J. Wishart and H. J. G. Hines. Jour. Min. Agric., 1929; *36*; p. 524. H. V. Garner and J. Wishart. Ibid., 1930; *37*; p. 793.

invited to repeat certain of the simple experiments. They operated on a very small scale with plots of 1/160 acre or less instead of 1/50 acre or more, but this was partly offset by painstaking attention to details of cultivation. Approved designs capable of ordinary statistical treatment were employed. This work has since developed and has proved advantageous both to the Station and to the schools themselves.(10)

In 1929 H. V. Garner took charge, and the work on the lines previously laid down was consolidated and extended to take in more centres and a wider range of crops. The field methods in use at this period, and the sampling procedure that enabled a start to be made on the study of cereal crops on commercial farms were put on record.(11)

From 1933 onwards much attention has been directed to the organisation of groups of experiments, uniform in design, made in as many areas as possible. The method had been used previously in the Institute of Brewing Series on barley in 1922, and the Basic Slag Committee Series on hay in 1926 ; but the extent and scope was widened when in 1933 the poultry manure investigations of the Ministry of Agriculture were put under the direction of the Station and still more when the Sugar Beet Series was undertaken with the co-operation of the Sugar Factories. Thanks to the managers and the agricultural staffs, and farmers concerned, experiments on sugar beet have been conducted on a scale quite out of the question under the previous arrangements. In 1927 only 12 sugar beet plots were harvested in addition to those at Rothamsted and Woburn ; by 1932 the number had risen to 660 ; but the effect of the factory scheme and the increasing co-operation of local workers has raised the plot number to 1,360 in 1938. The results are reported annually to the Sugar Commission. (12)

The operation of the poultry manure scheme had two important results. It brought under modern experimentation a series of market garden crops whose manurial requirements had hitherto been little studied ; and it called for new field designs to bring out direct, residual, and cumulative effects. This in its turn involved arrangements with the experimenters for maintaining the same experimental area under various treatments for a series of years with a rotation of crops. This type of work is likely to develop, as more attention is devoted to the long range effects of fertilisers especially of organic manures. Unfortunately it makes much more demand on all concerned than the usual type of annual experiment. The poultry manure results are collected each year both for the Ministry of Agriculture and in the Station Reports.(13)

The manuring of potatoes has been studied in important fen land and silt land areas with the co-operation of farmers anxious to test local practices. Thirty-one experiments have been made on

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(10) H. V. Garner. School Science Review, 1931 ; No. 48, p. 371. Ibid., 1937 ; No. 74, p. 258.

(11) H. V. Garner. Rothamsted Conferences, 1931 ; No. *13*, p. 49. D. J. Watson. Ibid., 1931 ; No. *13*, p. 54.

(12) Rothamsted Station Reports, 1933, p. 167 ; 1934, p. 215 ; 1935, p. 217 ; 1936, p. 241 ; 1937, p. 175 ; 1938, p. 000.

(13) Rothamsted Station Reports, 1933, p. 161 ; 1934, p. 206 ; 1935, p. 209 ; 1936, p. 233 ; 1937, p. 170 ; 1938, p. 000.

the black land and ten on the silt land since the series started in 1928. The results have been of considerable interest locally and have brought out the need for potassic and nitrogenous manuring in the black land area.(14) Other potato experiments were concerned with the relative values of the ordinary inorganic fertilisers and high grade organic manures, dried blood, steamed bone flour, and occasionally fish meal. No evidence of superiority of the organic forms could be obtained for the first crop, potatoes, indeed any difference observed was usually in the other direction.(15)

The increasing importance of kale in the root area led to experiments on its response to nitrogenous manures and on the effect of thinning out the plants in the rows. Many of these trials were made at the Midland Agricultural College.

In collaboration with Mr. A. W. Oldershaw of the East Suffolk County Council, some fruitful experiments have been started at Tunstall, bringing out quantitatively on the acid sand the effects on a rotation of crops of varying doses of chalk. Other experiments deal with the value of magnesian limestones and basic slags on acid soils, and the fertiliser requirements of sugar beet and potatoes.

More recently the fertilising value of treated town refuse has been tested at the outside centres but this work is for the moment in abeyance. The effect of granulation on fertiliser efficiency is being studied and this work is to be extended to include studies of the effect of the location of fertilisers in relation to the seed.

Precision attained

The degree of precision obtained in replicated experiments at outside centres compares favourably with that obtained in similar experiments carried out at the central experimental stations. For every experiment published in the Rothamsted Station Report the standard error of a single plot is recorded as a percentage of the mean yield of all the plots. In Table XXIV will be found these figures averaged over the period 1926-38 for the various classes of crops at Rothamsted and Woburn, and also at outside centres. They include all experiments with the exception of a few in which the crop was practically a failure, or where the agricultural notes showed that certain plots were seriously damaged by disease.*

TABLE XXIV

Standard Errors per plot, per cent. of mean yield—1926-38

	Rothamsted and Woburn		*Outside Centres*	
	No. of experiments	S.E. %	No. of experiments	S.E. %
Hay	2	10.9	36	8.6
Cereals	53	9.9	23	9.1
Potatoes	20	8.2	110	8.4
Sugar Beet	32	9.4	254	8.8
Roots (Mangolds, Swedes)	13	7.9	12	8.3
Kale	18	8.5	11	8.6

* The Standard Errors in these experiments were:—
Potatoes (main crop) 42.1, 22.7, 24.0, 21.0 per cent.
Potatoes (early) 54.0, 49.9. Sugar Beet 32.5, 25.6.
Kale 26.2. Oats 20.6.

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(14) H. V. Garner. Rothamsted Conferences, 1934 ; No. *16*, p. 4.

(15) Rothamsted Station Report, 1930, p. 32.

Experiments of equal size and the same design should therefore yield results of about equal accuracy whether made on an outside farm or an experiment station. Greater precision on individual comparisons may actually be secured at the experiment stations, however, since larger numbers of plots giving greater replication and higher accuracy can be handled in a single experiment than a busy farmer can cope with.

The magnitude of the standard errors obtained with vegetable crops has been recorded.(17) Owing to the smaller numbers of experiments the average values are less well determined than in the case of farm crops, but the figures indicate that, although vegetable crops are somewhat more variable than farm crops, the existing experimental methods can give definite and useful information on fertiliser questions. For micro-plots conducted at schools the standard errors are, as might be expected, as a rule somewhat higher than the normal values obtained from full-sized plots, but none the less the experiments have provided numerous results that attain statistical significance.(10) A brief summary of some of the main conclusions from work at the outside centres may now be given.

Barley. First Series 1922-1925: The yield of barley was influenced much more by nitrogenous than by phosphatic or potassic fertilisers. The two latter gave generally only slight increases on farms in which the root crops, and in some cases the seeds also, received additions of mineral manures. Soil and season had much greater influence on the nitrogen content of the grain than had manuring. Moderate use of nitrogenous manures (1 cwt. per acre of sulphate of ammonia) gave substantial increases in yield with no loss of malting value.

Ammonium Chloride. 1925-1928: On barley ammonium chloride was somewhat more beneficial both on yield and quality than sulphate of ammonia. On mangolds and sugar beet it was about equal but on potatoes it was less effective.

Green Manuring. 1924-1926: Trials with summer and autumn sown catch crops and with undersown crops were greatly hampered by the difficulty of establishing the green manuring crop. Even when grown and duly ploughed in, the following crop was in most cases only slightly benefited. The few experiments that succeeded show that green manuring can give good results under correct conditions.

Basic Slag. The work on basic slag and rock phosphates has been too extensive to admit of any adequate brief summary. Dr. E. M. Crowther has recently discussed the results,(16) and they are reported in full annually to the Basic Slag Committee of the Ministry of Agriculture. The yield of hay and of repeatedly mown grass, and the recovery in the herbage of added phosphoric acid, showed a fairly close relationship with the citric solubilities of the slags employed. Rock phosphate was much more active on acid

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(17) Rothamsted Station Report, 1935, pp. 32-42.
(10) H. V. Garner. School Science Review, 1937; No. 74, p. 258.
(16) E. M. Crowther. Jour. Roy. Agric. Soc. Eng., 1934; *95*, p. 34.

than on neutral or alkaline soils. The improvement in the phosphoric acid and calcium content of herbage following phosphatic manuring was often very considerable.

Potatoes on Fenland Soils. There are two types of black soils: (1) light fen soils resting on a thick bed of similar unweathered material underlain by clay, which, however, is not brought up to the surface; and (2) the heavier soils in which the surface soil has had recent artificial additions of clay, or where the clay subsoil is so close to the surface that a certain amount of admixture takes place by very deep ploughing. In the first type potatoes have responded well to potash, usually to nitrogen also, and to moderate doses of superphosphate, 5 cwt. per acre. The heavy fens, on the other hand, have so far shown little need for potash, but they respond to heavy dressings of both nitrogen and phosphate.

Potatoes on Silt Land. These soils in the Wisbech area have been very highly farmed for a long period. Under these circumstances maximum yields have been obtained by the use of only moderate dressings of artificials as distinct from the exceedingly heavy dressings locally in favour. The experiments are being repeated in the same plots to ascertain whether the observed effect holds for one year only or whether smaller dressings will now suffice for a series of years. Nitrogen and phosphate have proved more important than potash on these good silts, especially when dung is applied.

Dried Poultry Manure. As a source of nitrogen, dried poultry manure is only about 2/3 as effective as sulphate of ammonia in its year of application. The design of the experiments enabled residual and cumulative effects to be investigated but these turned out to be small even when the dressings had been repeated for four years on the same plots. The experiments had special value in directing attention to the manurial responses given by market garden crops grown under normal commercial conditions,(17) and also in developing the technique of estimating the yield of crops harvested on a number of successive occasions.

Concentrated Organic Manures. Dried blood and steamed bone flour, or fish meal, were never superior for potatoes to ordinary mineral fertilisers providing equal nutrients, and occasionally they were significantly inferior.

Sugar Beet. Numerous sugar beet experiments are in progress under the scheme of sugar beet Research and Education and the present results have been summarised.(18) Sulphate of ammonia is in all soils and seasons the most consistently effective of the fertilisers tested. It is least effective in fen land soils and in very dry summers. Three to four cwt. per acre may be used with confidence on mineral soils and in normal seasons. It markedly increases the tops and is as effective at the higher as at the lower dressings. It reduces the sugar percentage in the roots by about 0.1 per cent. per cwt. applied, but this disadvantage is more than offset by the much larger yield increase.

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(17) Rothamsted Station Report, 1935, pp. 32-42.

(18) E. J. Russell. British Sugar Beet Review, 1938; *12*, p. 109. H. V. Garner. Ibid., 1939; *13*, p. 41.

Muriate of potash had done well throughout the series especially on light and fenland soils. Its effectiveness is increased when used with a nitrogenous manure and a balance between these two should always be maintained. Potash increases the sugar percentage by about 0.1 per cent. per cwt. applied.

The effect of phosphate depends on season and on soil type. Coarse sands and fenland soils have uniformly responded to moderate dressings of phosphate (3 cwt. per acre), and in a few experiments a heavier dressing of phosphate had been justified.

Kale. Kale responds readily to nitrogenous manures, giving an average increase of approximately 1 ton of green stuff per 1 cwt. of nitrogenous manure applied. The increase is smaller, however, in exceptionally dry summers, or where high yields (35 tons or more) are obtainable without additional nitrogen. Thinning the plant in the rows tended to reduce rather than increase the yield per acre.

Town Refuse. A treated town refuse applied at the rate of 12 tons or more per acre gave promising results in the year of application, its nitrogen having approximately one half the value of that of sulphate of ammonia.

Liming Materials. Experiments on liming have been conducted mainly on the acid sands of East Anglia and in particular on the Tunstall experimental farm. On these acid sands a small dressing of ground chalk has had remarkable effects. At Tunstall 1 ton of calcium carbonate per acre has acted for seven years, giving five excellent crops of sugar beet, one good crop of barley and a useful crop of red clover on land which previously would carry none of these crops.

Comparisons of ground limestone with ground dolomite showed no difference so far as the sugar beet crop is concerned.

Further Developments. The experience of the past ten years has shown that modern methods of field experimentation may be applied to root crops with complete success without appreciable disturbance to the routine of a commercial farm. Crops harvested on several successive occasions, such as Brussels sprouts or French beans, require considerable extra supervision and the experiments must be either fairly accessible to the research station or mainly under the control of local workers. Hay experiments also can be undertaken at outside centres but in catchy weather the weighing of the produce may be protracted, necessitating the presence of a recorder for several days.

Cereal crops present more difficulties. The large barley plots of the early experiments were harvested in the ordinary farm way, but this is out of the question for modern small replicated plots. Several alternatives have been tried.

(1) A number of small random samples cut with shears at the ordinary stubble level are taken from each plot, transported to Rothamsted and threshed in a special small machine. The yield per acre is then calculated from the areas actually sampled.

(2) The produce of every plot is weighed on the field and a sample is taken from each plot either (*a*) by random selection of a sheaf and random sampling within that sheaf, or (*b*) by grab sampling either from sheaves or loose produce. All the samples are

taken to Rothamsted and the ratio of grain to total produce is determined by small scale threshing as before, and the grain yield is then calculated.

Several difficulties still remain. Small scale harvesting necessitates a certain amount of walking about in the standing crop especially when sampling from the standing crop by the method first described, and this naturally does not commend it to farmers. The second method requires expert scythesmen who are not always available. Cereal harvest also is a time of greater stress than root harvest and extra hands for experimental work are not easy to obtain. It is further necessary to induce farmers who have already carried out an experiment in roots to continue the existing plots in the following cereal crop. This is not always easy because the main effect of the manures has been shown in the roots with comparatively little effort, while the problematical and certainly subsidiary residual effects in corn involve additional trouble. Bad weather moreover tends to keep the field staff stationed away from home for longer periods when engaged on cereal experiments than on roots. Field weighing of roots can be done under weather conditions that would stop corn harvest for several days.

None the less the successful carrying out of cereal experiments is an essential development at outside centres, for only in this way will the full study of fertiliser effects be possible. Many of the sugar beet experiments and almost all tests of organic manures and liming materials involve the harvesting of cereal crops for their complete examination.

INSECT PESTS AT ROTHAMSTED AND WOBURN, 1938

A. C. EVANS

GENERAL

Little trouble has been experienced from insect pests this year. No further occurrence of the Wheat Mud-beetle has been recorded.

WHEAT

Wheat Blossom Midges (*Sitodiplosis mosellana* Géhin and *Contarinia tritici* Kirby) have decreased considerably in number.

	Number of Larvae per 500 ears	
	1937	1938
C. tritici ..	2,558	378
C. mosellana ..	3,409	765

KALE

On Fosters, Flea Beetles (*Phyllotreta* spp.) severely damaged the seedlings which survived a dry period in early summer.

SUGAR BEET AND MANGOLDS

The Black Bean Aphis (*Aphis fabae* Scop.) was rather plentiful on the mangolds and sugar beet on Barnfield and the Long Hoos experiments in early July but the plants grew away successfuly and no obvious damage was done.

BEANS

The spring Beans on Great Harpenden were ruined by the Black Bean Aphis. The winter Beans on the same field were badly attacked in places. Spraying was not practicable owing to the density of the plant.

WOBURN

No serious pests were noted. Aphids (various species) were common on several crops but no obvious damage was done.

FUNGUS DISEASES AT ROTHAMSTED AND WOBURN, 1938

MARY D. GLYNNE

GENERAL

The dry season of 1938 produced differences in the incidence of several diseases compared with the wet season of 1937. Thus Eyespot Lodging of wheat caused by *Cercosporella herpotrichoides* Fron. was much less severe than previously and Brown Foot Rot of wheat caused by *Fusarium* sp. was more frequent than usual.

WHEAT

Eyespot Lodging (*Cercosporella herpotrichoides* Fron.) produced no general lodging of wheat on Broadbalk in 1938 when the average percentage culms infected at harvest in the whole field was estimated as about 40 per cent. In 1937 lodging had been very severe with over 80 per cent. of the culms infected at harvest. In general, observations have indicated that serious lodging is caused by the disease only when about 80 per cent. or more of the culms are infected. Individually lodged culms could be seen lying criss-crossed in the otherwise apparently upright crop on Broadbalk in 1938 and these showed a high percentage infection while upright culms showed a low percentage. The disease was found in 1938 on Hoosfield on the Alternate Wheat and Fallow Experiment to a less extent than on Broadbalk. It also occurred, but on relatively few culms, on some of the wheat grown in rotation at Rothamsted.

" Eyespot Lodging " was approved in December, 1938 by the Plant Pathology Committee of the British Mycological Society as the common name of the disease caused by *Cercosporella herpotrichoides* Fron.

White Straw Disease (*Gibellina cerealis* Pass.) was first found in 1935 on Hoosfield on the Alternate Wheat and Fallow experiment and to a very small extent on the adjacent plot of the Soil Exhaustion experiment. As the only other records of this disease show that it has occurred in Italy, Hungary and as a rarity in central France it has rather a special interest. It re-appeared in the Alternate Wheat and Fallow experiment in 1937 when the B series of plots cropped in 1935 again bore wheat, but none could be found in 1936 on the A series of plots. It was a little surprising therefore that in 1938 when the A plots were next cropped more diseased plants were found than in 1935 or 1937. The disease caused severe damage to the plants attacked but these formed only a small proportion estimated in 1938 as 1 to 5 per cent. of the total number.

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No sign of the disease could be found on Broadbalk or on any other wheat grown at Rothamsted or Woburn.

Brown Foot Rot (*Fusarium* sp.) was more than usually frequent at harvest, sometimes causing individual culms to lodge or to produce whiteheads. Its incidence varied on different plots on Broadbalk and showed some tendency to be greater on the plots receiving heavy nitrogen. On these and on some of the commercial wheat crops as many as 33 per cent. of the culms showed signs of infection at harvest, but of these only a small proportion were attacked severely enough to cause either lodging or whiteheads.

Take-all (*Ophiobolus graminis* Sacc.). The season was in general not very favourable to this disease. It was found, but infrequently, on Broadbalk at Rothamsted. On the Continuous Wheat experiment on Stackyard field at Woburn the disease had increased as compared with the previous year and its distribution in relation to manurial treatment showed a close similarity to that found in the years 1931-33 before it was fallowed in 1934 and 1935.

Mildew (*Erysiphe graminis* DC.) was moderate at Rothamsted, being more severe where heavy dressings of nitrogen were applied.

Loose Smut (*Ustilago Tritici* (Pers.) Rostr.) was slight both at Rothamsted and Woburn.

BARLEY

Take-all (*Ophiobolus graminis* Sacc.) was slight on the Continuous Barley plots at Rothamsted and Woburn and moderate after green manure on Lansome field, Woburn.

Brown Foot Rot (*Fusarium* sp.) was slight at Rothamsted.

Mildew (*Erysiphe graminis* DC.) was slight.

Leaf Stripe (*Helminthosporium gramineum* Rabenh.) occurred occasionally on the Commercial Barley on Lansome field, Woburn, where untreated seed saved from the farm had been used. On the Green Manure and other experiments where commercial seed already treated was used, the disease was absent. Leaf stripe used to occur frequently but since the almost universal adoption of seed treatment by commercial firms it has now practically disappeared except when untreated seed is used.

GRASSES

Choke (*Epichloe typhina* (Fr.) Tul.) occurred as usual on *Agrostis* on the grass plots and was most plentiful on the acid plots where also *Agrostis* is most frequent. It was rather more abundant than in 1937, when however there was rather less than in previous years.

CLOVER

Rot (*Sclerotinia Trifoliorum* Erikss.) caused death of some plants and of the outer leaves of others in the early spring and previous autumn both at Rothamsted and Woburn.

BROAD BEAN

Botrytis spp. causing two types of lesion, the limited, known as "Chocolate Spot," and the unlimited type, was unusually slight at Rothamsted.

POTATO

Virus. Leaf Drop Streak was fairly common at Woburn on Butt Furlong field.

Blight (*Phytophthora infestans* (Mont.) de Bary) was observed as slight on the Four-course experiment on Hoosfield in August.

FARM REPORT, 1938

Weather

The outstanding weather feature of the year 1937-38 was the severe drought during the spring and summer months. The total rainfall for the year was only 20.084 inches compared with last year's total of 35.859 inches and the 85-year average of 28.710 inches. Ten of the twelve months had rainfall below the average, and the six months April to September only had 8.144 inches compared with the average of 14.029 inches. The winter was generally mild and there were only two frosts of any severity. Mean temperatures were slightly above average. There was an extremely warm and sunny spell in March, but the total sunshine for the year was below normal.

Weather and Crops

Conditions from late autumn to early spring were generally favourable to farm work, and all root crops were gathered under good conditions. The land which was ploughed by the end of 1937 worked down well in spring and good seed beds were obtained early for the spring cereals. Owing to the absence of frosts the late ploughed land was difficult to work down. The continuous dry weather soon slowed down growth of all corn crops and towards the end of May most crops were turning yellow. However the little rain which fell at the end of May brought about an immediate change in the corn and bean crops. These started to grow rapidly and changed to a darker and more uniform colour. The continuation of the drought did not appear to affect the corn crops after this, and yields were exceptionally high. Although the weather conditions gave rise to excellent yields of grain, the straw yields were not correspondingly high, and in many experiments the yield of grain was higher than the yield of straw.

The root crop areas which were worked down early produced good seed beds, but those that were not worked down by the middle of March dried out into hard unworkable lumps, and good seed beds were difficult to obtain. Yields of beet were rather poor, but the weight of the tops was in most cases up to average and was well above the weight of roots. Sugar percentages were low.

The dry weather during the summer enabled the weeds to be kept under control easily. The germination of seedlings was slow and they were far less numerous than usual. The stubbles were far cleaner than usual, and as these had been softened by storms during harvest they were in good condition for working. Advantage was taken of this and all stubbles were cleaned either by shallow ploughing or cultivating, followed by several harrowings.

The experiment on newly-ploughed-up grassland, to determine the best crop to utilise the stored-up fertility, could not be commenced, although some of the preliminary work was carried out. The ground during the summer was far too hard for ploughing, and by the time the ground was soft enough the season was too far advanced to expect reasonable autumn sown crops. The ploughing will now be done in the late winter of 1939, and the autumn-sown crops will be replaced by the same crops to be sown in the spring.

Classical Experiments

Broadbalk was ploughed in September, only the one ploughing being given. Drilling took place rather later than usual as we waited for rain before commencing this operation. The wheat looked exceptionally well throughout the year, and at harvest every plot was standing well. This is the first occasion for many years that all plots were standing at harvest. Some of the plots ripened earlier than others so the cutting was done at two different times. There was some bird damage both before cutting and while in the stooks, but the damage was not so severe as in past years. Sections I and II of the dunged plots contained a lot of wild oats but otherwise the field was much cleaner than usual.

The wheat plant on Hoosfield Halfacre was rather thin, but the straw was long and the ears of good size. Before harvest the crop looked better than it had for many years. There was no sign of wireworms or wheat bulb fly damage.

Hoosfield barley plots worked down to a nice seedbed, and sowing was done in late February under excellent conditions. The plant looked well early, but late frosts and lack of rain caused a slight setback. However, the barley grew away later, and at harvest was an excellent crop with all plots standing.

In Agdell field the clover looked a nice even plant in autumn, but much was killed off during the winter by *Sclerotinia*. However a fair plant remained, the plot which received full manuring for the root break looking poorest. Very little growth took place until late in May but then growth started fairly quickly after rain. The plot receiving mineral manures only stood out as having the best plant and making the greatest growth.

Barnfield was ploughed rather late, and considering the few frosts there were, the land worked down quite well. All seedbed preparations were done when the soil was dry, and the land was ready for sowing by the end of March. Sowing was postponed in the hope of rain, but as none had fallen by early May drilling was done. The plant came through rather slowly but a good thick plant was finally established. Singling was difficult owing to the hard state of the ground. Fair growth was maintained throughout the season and yields were almost up to average. Weeds were kept under control easily as the dry weather retarded their germination and growth.

Modern Long-Term Experiments

Four Course Rotation. The wheat was sown under good conditions and came through nicely, though it became a little patchy later. The crop evened out before harvest and though the straw was short the yields of grain were very good. The barley was sown in a fair seedbed but much of the seed was taken by birds shortly after drilling. The crop looked rather gappy and uneven, and throughout the year was the most backward barley on the farm. However, yields were up to average, the grain yield being above the straw yield. The ryegrass was sown late and germination was extremely slow. Only a thin plant was established and subsequent growth was slow. A little growth of flowering heads took place in May but there was no bottom grass, and yields were very low. The wheat stubble for potatoes was ploughed across the usual way, and the second ploughing was done across these furrows. The land worked down quite well but the sets were planted rather late. The crop looked poor throughout the season and yields were low.

Six-Course Rotation. The clover stubble was ploughed early to give a bastard fallow before the wheat crop. The wheat looked well throughout the season and had a remarkably dark colour. Grain yields were well above average but straw yields were low. The mustard catch crop between the rye and sugar beet made very little growth. The seedbed for beet worked down well, but sowing was delayed in the hope of rain. The yield of roots and the sugar content were low and there was more weight of tops than of roots. The clover plant was thick and even, and looked well in spring. However growth during the summer was very slow and the crop was not cut until the end of June. The wheat stubble was ploughed early so that a second ploughing for potatoes could be made later. The rye crop to be ploughed in as green manure was omitted this year so that better tilth could be obtained for potatoes. A good tilth was obtained and the crop looked well throughout the season. Yields were about average despite the dry season. Barley and rye was drilled under good conditions and good growth was maintained throughout the season. Yields of grain were well above average but straw yields were low, there being more weight of grain than of straw in the barley crop.

Three-Course Rotation. (Straw and Adco.) The green manure crops were omitted this year for the first time. In past years these crops were ploughed in shortly before sowing, and as the last ploughing prevented much weathering action on the soil good seedbeds were difficult to obtain. This year instead of ploughing each break as it was cleared, the ploughing was delayed until the whole area was cleared and then the ploughing was done across the usual direction of ploughing. This will be the procedure adopted in future years. All three breaks were partly worked down together in early spring, and good tilths were obtained for barley and potatoes. These crops did very well throughout the season and gave excellent yields. The sugar beet break was not worked down to the final seedbed until much later, and by this time the soil had dried out. The plant had a poor start and there were many gaps. Growth throughout the season was slow but yields were lower than were estimated owing to the high proportion of tops.

Three-Course Rotation. (Cultivation.) This experiment was slightly modified this year. Each of the three methods of cultivating the ground was done at the most suitable time, and not all at the same time as hitherto. The usual shallow ploughing of the wheat stubble was attempted but had to be abandoned. On some plots the plough sank in deep and on others it would not enter the soil. The area was therefore cultivated both ways and the rubbish pulled out was carted off. Ploughing for mangolds was done in the winter, and the cultivator was used twice in late winter. The rotary cultivation was delayed until mid-May as the ground was too hard for the Simar. Germination and growth were very slow, and weeds were thick in the rotary cultivated plot. Yields were very poor. For wheat the ploughing and tine cultivation were done earlier than usual, and the tine cultivation was repeated shortly before drilling. The rotary cultivation was done just prior to seeding. Much of the seed was taken by birds, and throughout the season the plant looked poor, thin and weedy. The rotary and tine cultivated plots were most weedy, the ploughed plots standing out as better, taller and thicker plants with fewer weeds. On the barley break the eastern row of plots came through badly and they would have been redrilled had rain come. The ploughed plots seemed the most damaged. The western row of plots came through fairly well, but at harvest both ears and straw were short. The eastern row remained thin and backward and ripened late. Over the whole break the rotary cultivated plots seemed most forward throughout the season and they ripened earlier. This is borne out in yields, though the yields of grain and straw were low.

Annual Experiments

Wheat after different Leys. The crop looked well throughout the season and plot differences were soon noticeable. The plots after the ryegrass ley were noticably more backward and yellow. All plots yielded well, the best treatments yielding up to 64 bushels per acre.

Kale. The experiment testing town refuse with sulphate of ammonia and dung was only slightly attacked by flea beetle and a good plant was left. Growth was maintained until late in the season.

The first sowing of the experiment testing various forms of organic manure was destroyed by flea beetles, but the second sowing survived. Growth was slow but the discoloration of the plant noticed last year on this experiment did not re-appear.

Sugar Beet. The land was ploughed early but the ground dried out before a tilth was obtained, and sowing was therefore delayed. Sowing finally took place on a rather rough tilth but a fair plant came through. An even plant was left after singling, which grew until late in the season. There was good growth of tops but roots were rather small and fangy. The roots averaged nearly 9 tons per acre of washed beet, while tops averaged 15 tons per acre. The sugar content was low (average 15.6%) but bolters were almost entirely absent.

Potatoes. The land was ploughed rather late but worked down to quite a good tilth. The plants came through well and good growth was maintained despite the drought. The crop was not sprayed but only a few of the tubers were blighted. Yields were good, the best treatments yielding up to 15 tons per acre with an average of 12½ tons per acre, and the proportion of ware was high.

Clover. The plant in Great Harpenden field was rather thin but was spread evenly over the whole area. Little growth was made until late May and then the crop grew fairly fast. The ground became well covered and there were very few weeds. Cutting was delayed until early July, and a fair cut was obtained.

Non-experimental Cropping, 1937-8

The non-experimental corn crops were affected by the spring drought but the rain which fell at the end of May brought about an immediate change in the crops. The crops looked well during the remainder of the season and only one field was lodged. The yields were higher than were expected as the straw was generally rather short, the oat straw being especially short. The wheat averaged 54 bushels per acre, the barley 64 bushels per acre and the spring oats 74 bushels per acre. All crops except the oats were threshed and sold before the end of September.

The winter beans which were ploughed in with dung in Great Harpenden field looked well forward and clean until July, but the crop was then attacked by bean aphis. The beans were too tall to allow spraying and the attack ran its course, but the yield was reduced by about half. The part of the field under spring beans did poorly as the drought severely retarded growth. The aphis first attacked the spring beans and spread from them to the winter crop.

Little Hoos field was ploughed up late after folded kale and was too hard to work down until the middle of May. It was drilled on May 23rd with Abed Kenia barley, a quick growing variety with a stiff straw. Growth was rapid for the first few weeks but then slowed down, and had stopped completely by early July. Although the plants were only 6 inches to 8 inches high they showed signs of coming into ear, and the crop was therefore folded off with sheep for which there was no other keep.

The kale plant on the various fields was attacked by flea-beetle which severely thinned the plant. However, enough was left to warrant leaving the crop and heavy doses of sulphate of ammonia were given to hasten growth. Part of the plant on Foster's field was completely destroyed and had to be re-sown. Growth during the autumn was rapid but much was destroyed by frosts and pigeons during the very cold spell late in 1938. The heavy doses of sulphate of ammonia appeared to make the kale more susceptible to damage by frost. Long Hoos VII which had received 20 tons of compost per acre in addition to nitrogen gave the best yield.

The non-experimental potato land worked down quite well and growth throughout the summer was good. The rain which fell in August kept the haulms green longer than usual, and lifting was delayed by rain early in October. Yields were quite good and only the King Edward VII variety was attacked to any appreciable extent by late blight. Selling prices throughout the winter were very low.

E

High Field Grazing Experiment

This experiment is designed to compare the manurial value of feeding stuffs fed to stock on grassland with the conventional estimates of the manurial value of the cake, applied as fertilisers. The arrangement is described on page 25 of the 1937 Station Report. The season 1937 was used to develop technique and to conduct a uniformity trial on all the plots, while the 1938 season was the first in which experimental treatments were given.

Before grazing commenced two extra strands of wire were added to the fences to make them completely stockproof, and eight cages were put on each plot so that samples of the herbage for botanical analysis could be taken later in the season.

The plots were grazed from the end of April until mid-June, the rate of stocking being adjusted on each plot to suit the growth of grass. During this period 828 lbs. each of flaked maize and undecorticated cotton cake was fed on each " cake " plot. The stock was removed owing to shortage of grass. All plots remained empty until mid August and were then grazed with varying densities of stock until October 4th when the plots were cleared for the season. During the second grazing period 1,650 lbs. of each flaked maize and decorticated groundnut cake was fed on each " cake " plot. In order to get the amount of cake fed close to the amount which would be fed in a year with a normal growth of grass, the two " cake " plots were grazed more heavily than the grass warranted.

The stock used this season were forward blue-grey bullocks on the plots receiving cake, and blue-grey heifers on the other plots. The sheep used were Halfbred ewe tegs.

Estate Work

The badly overhanging trees around Appletree field have been severely lopped and trimmed.

A new automatic electric water pump has been installed at the well, and has been suitably housed. There is a pressure tank at ground level which has enabled us to dispense with the two unsightly water towers. Water has been laid on from the farm to the two cottages on the Redbourn Road.

The foundation of the Roman Temple and surrounding wall near the buildings have been built up in cement to prevent disintegration, and the surrounding area has been levelled off.

Grassland

The grass remained very green throughout the winter but very little early growth was made. Most of the fields were harrowed in the spring. The most serious effect of the drought was on the grassland. There was no flush of grass in the spring, and during the summer the grass made but very little growth. Full winter rations, including hay, were fed to cattle into May, and ewes with lambs had to be fed until the end of May, four weeks longer than usual. Owing to the shortage of grass no fields were shut for hay and none of the fields required topping as the stock ate the flowering heads. However the mower was put over most fields to cut thistles. There was no grass or aftermath for the lambs after weaning so they were folded on a late sown crop of barley which had stopped growing. The grassland remained bare until late September but rapid growth then took place. The fields were more green in October than at any time during the summer.

Livestock

Horses. Two horses have been disposed of owing to advancing age, and two useful young horses have been bought to replace them. There are now three teams, all fairly young horses : two of the teams are Suffolks and the third team are crossbred horses which are only worked together at busy periods.

Cattle. The Kerry heifers which were bulled to calve in the spring of 1938 were out-wintered, and received only poor quality hay, but they remained in fair condition. They calved down early in the summer and did their calves quite well on the little grass they had. The heifers were bulled again to calve in the spring of 1939. The calves were weaned early in November into a field with a covered shelter, but during the rough weather late in 1938 they were brought into covered yards. They were turned out at the end of March, 1939, and their food was gradually stopped. Between weaning and turning out they received an average of 4 lb. per head per day of a concentrate ration in addition to hay. They were sold early in May and fetched £13 5s. 0d. each.

The Blue-Grey heifers from the High Field grazing experiment were taken over by the farm when they came off the plots.

Sheep. Owing to the large number of lambs sold by October 1st, 1937 (217 had been sold) we had rather more kale than was needed for winter keep, so 90 store tegs were purchased and fattened off on the kale with the remainder of our own tegs. All were sold by early February before prices dropped.

For the 1938 lamb crop Hampshire rams were used on the Halfbred ewes. Hay and beet tops were fed until January and then the ewes were folded on kale each day. Lambing started at the end of February and concentrate feeding was commenced as the ewes went into the lambing field. Weather conditions during lambing were almost ideal, and both ewes and lambs did well. Of nearly 250 ewes lambed only 3 died through lambing. The final lambing figure for the Halfbred ewes was 157 per cent. 216 of the 1938 lamb crop had been sold by the end of September, but prices were very much lower than in past years.

The Suffolk ewes purchased in the autumn of 1937 were sold after rearing their lambs. The ewes were rather disappointing in that their lambs were very small and their lambing percentage was only 120. The ewes seemed more liable to foot trouble than did the Halfbreds, and they did not appear suitable to our conditions and requirements.

Pigs. During the early winter months the old cow standings and old manure shed were converted into farrowing pens, and the litters reared in them did far better than did those in the piggery.

The fattening pigs did fairly well during the summer and sales for the year totalled 297. Owing to the unsatisfactory housing conditions it was decided to disperse the herd, and all the sows were sold. The fattening pigs were kept on until most of them had reached bacon weight. A new herd will be started immediately new housing is provided.

Shows. No entries were made at any of the Agricultural Shows during the year. At the Redbourn Agricultural Competitions C. Mepham and F. Stokes were both placed for their horse ploughing, and they secured first and second places respectively for turnout, Mepham also being reserve champion for the best turnout in the field.

Staff. A. F. Howell, the farm recorder, left in September, 1938, and G. W. Wilcock was appointed to the post.

Implements

The following implements have been presented or loaned to the farm by the manufacturers. The firms to whom we are indebted are as follows :

Allen & Simmonds, Ltd.	Motor hoe.
Bamfords, Ltd.	Hay machinery.
E. H. Bentall & Co., Ltd.	Cake breaker.
Blackstone & Co., Ltd.	Swathe turner.
Cooch & Sons.	Potato sorter.
Cooper, McDougall & Robertson, Ltd.	Sheep dipper.
Cooper, Pegler & Co., Ltd.	Spraying machinery.
The Cooper-Stewart Engineering Co., Ltd.	Sheep shearing machine.
Dunlop Rubber Co., Ltd.	Rubber wheels.
R. G. Garvie & Sons.	Grass seed broadcaster.
General Electric Co.	Electric motors.
Harrison, McGregor & Co., Ltd.	Root pulper, manure distributor.
R. A. Lister & Co., Ltd.	Oil engine, sheep shearing machine.
Parmiter & Sons, Ltd.	Rake and harrows.
Ransomes, Sims & Jefferies, Ltd.	Ploughs, cultivators, grass rejuvenator.
J. Wallace & Sons, Ltd.	Manure sower, potato planter.
J. Wilder.	Pitch-pole harrows.
W. A. Wood & Co., Ltd.	Mower, spring tine harrows.
The Harvest Saver & Implement Co.	Prime Electrical Fence.

METEOROLOGICAL OBSERVATIONS

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

The following observations under this scheme are taken daily, at 9 a.m. G.M.T. :

> *Temperatures*—maximum and minimum in screen, minimum on grass, 4 inches and 8 inches under bare soil, dry and wet bulb in screen ; *Rainfall*—8-inch gauge ; *Sunshine*—duration by Campbell-Stokes recorder ; *Weather*—Beaufort letters ; *Wind*—direction and force ; *Visibility ; State of ground.*

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

The above observations are supplemented by the following records, for the use of the Meteorological Office :

> *Barometer and attached Thermometer ; Solar maximum* ; Temperature*—1 foot under bare soil : *Cloud*—amount, form and direction ; *Sunshine*—hourly values of duration. With the exception of the last, all these observations are also taken at 9 a.m. G.M.T.

The following additional observations are also made, to maintain the continuity of the Rothamsted meteorological records :

> *Temperatures under grass* at 4 inches, 8 inches, and 1 foot, taken at 9 a.m. G.M.T. ; *Wind*—direction and force at 3 p.m. and 9 p.m., G.M.T., taken from chart of recording anemo-biagraph ; *Rainfall*—5-inch gauge taken at 9 a.m. G.M.T.

Radiation.—A Callendar Radiation Recorder (on loan from the Imperial College of Science) gives a continuous record of the radiant energy falling on a receiver situated on the roof of the laboratory. The records are compared with those for South Kensington, and are also used in plant physiological studies in the Station. A Gorczynski Radiometer for measuring the radiant energy of the sun has also been installed, under the Agricultural Meteorological Scheme.

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

Three drain gauges, each of one-thousandth of an acre in area, originally installed by Lawes in 1870, and fitted with continuous recorders in 1926, give the drainage through 20 inches, 40 inches, and 60 inches of uncropped and undisturbed soil. A continuously recording 6-inch gauge is used in conjunction with these.

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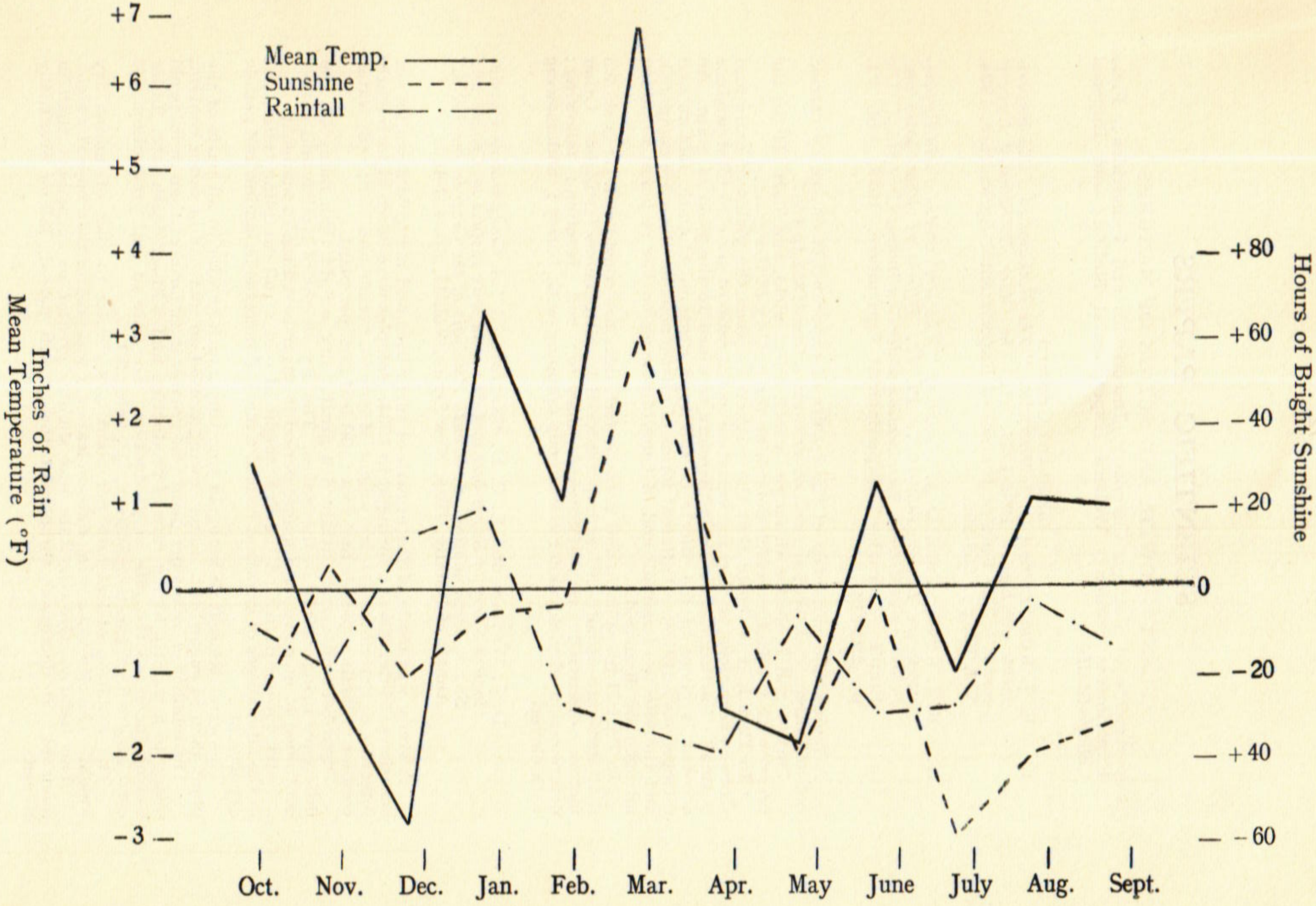
* Discontinued October, 1935.

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

Atmospheric Pollution.—A gauge for measuring the amount of solid matter deposited from the atmosphere has been in use for some years in connection with the scheme of observations arranged by the Atmospheric Pollution Research Committee of the Department of Scientific and Industrial Research. In February, 1933, a gauge for measuring atmospheric sulphur dioxide was also set up.

DEVIATIONS FROM MONTHLY AVERAGE VALUES. OCT., 1937—SEPT., 1938.



SCIENTIFIC PAPERS

PLANT GROWTH, AND ACTION OF MANURES

(Departments of Botany, Chemistry, Insecticides and Fungicides; Field Experiments Section; Woburn Experimental Station; and Imperial College Staff.)

(*a*) PLANT GROWTH

I. E. J. RUSSELL and D. J. WATSON. "*The Rothamsted Field Experiments on Barley* 1852-1937. *A. The Older Rothamsted Experiments.*" The Empire Journal of Experimental Agriculture, 1938, Vol. VI, pp. 268-292.

II. E. J. RUSSELL and D. J. WATSON. "*The Rothamsted Field Experiments on Barley* 1852-1937. *Pt. II. Effects of Phosphatic and Potassic Fertilizers; Deterioration under Continuous Cropping.*" The Empire Journal of Experimental Agriculture, 1938, Vol. VI, pp. 293-314.

A review and summary of the results of experiments on barley carried out at Rothamsted, Woburn and other centres from 1852 to 1937.

Parts I and II deal with factors which affect yield, and Part III (in the press) with the factors which determine the quality of the grain.

In Part I, it is shown that the relation between the yields of grain and straw is very close, so that the variation in the ratio of grain to total produce is small. Further discussion is therefore confined to the yield of grain. An account is given of the effects of soil type, seasonal climatic factors and nitrogenous fertilizers. Different forms of nitrogenous fertilizer are compared, and the effects of rainfall and of time of sowing on the response to added nitrogen are discussed.

In Part II phosphatic and potassic fertilizers are considered. It is shown that these are usually of less importance than nitrogenous fertilizers. Other factors discussed are:—farmyard manure; soil reaction; fallowing; deterioration of yield under continuous cropping with barley; undersowing with clover.

III. D. J. WATSON and E. C. D. BAPTISTE. "*A Comparative Physiological Study of Sugar-beet and Mangold with respect to Growth and Sugar Accumulation. I. Growth Analysis of the Crop in the Field.*" Annals of Botany, 1938, New Series, Vol. II, pp. 437-480.

A study was made of the growth of sugar-beet and mangold sown on six occasions at intervals of a fortnight in 1934. Samples were taken at fortnightly intervals to determine (1) dry weight of lamina, petiole and root; (2) water content of lamina, petiole and root; (3) leaf area per plant.

Sugar-beet ultimately attained a greater dry weight than mangold, the difference being mainly in the leaves. The dry weight of lamina and petiole continued to increase for a longer period in sugar-beet than in mangold.

Later sowing decreased the dry weight of root at all sampling times, but in the later stages of growth it caused a marked increase in lamina and petiole dry weights.

The water content of mangold was very much greater in all parts of the plant than in sugar-beet. Later sowing caused an increase of water content.

The number of leaves per plant was greater in sugar-beet than in mangold owing to a slightly higher rate of production and a lower death rate. Later sowing increased the rate of production. The rate of leaf production was correlated with mean temperature, Q_{10} being 3.1.

The variation of leaf area per plant was similar to that of lamina dry weight. The effect of sowing date on leaf area was greater than on leaf weight.

The Relative Growth Rate was slightly greater in sugar-beet than in mangold; it decreased throughout the growth period, falling eventually to zero.

Later sowing increased the Relative Growth Rate in the early stages, due to an increase in the Leaf Weight Ratio ; Unit Leaf Rate was unaffected by date of sowing.

IV. D. J. WATSON and I. W. SELMAN. "*A Comparative Physiological Study of Sugar-beet and Mangold with respect to Growth and Sugar Accumulation. II. Changes in Sugar Content.*" Annals of Botany, 1938, New Series Vol. II, pp. 827-846.

An account is given of the changes during growth in the sucrose and reducing sugar content (expressed per 100 g. of dry matter and per 100 g. of water) of the lamina, petiole, and root of sugar-beet and mangold sown on six occasions in 1934.

Sugar-beet had a higher content of both sucrose and reducing sugars than mangold, except that the sucrose content of the lamina was almost the same in the two plants, and in the root the reducing sugar content was greater in mangold. In general, both the sucrose and reducing sugar content of all parts of the plant increased steadily with time.

The sucrose content increased through the plant in the direction from lamina to root. The reducing sugar content was highest in the petiole, and was greater in the lamina than in the root. It is pointed out that this does not necessarily imply that translocation takes place against a gradient of sugar concentration, for gradients falling in the direction of movement may exist in the conducting tissues, which are masked in the mass analyses of lamina, petiole, and root. The data give little direct evidence on the mechanism of translocation, but they serve to illustrate some fallacies in the arguments of Davis, Daish, and Sawyer for the view that sucrose in the leaf is an immediate product of photosynthesis and that carbohydrate is translocated as hexose.

There is no clear distinction in the root between a phase of growth and a phase of sucrose storage, for the very young roots have a high sucrose content. Growth and accumulation of sucrose proceed together.

On the mean of all sampling times, a significant increase of sucrose content was found in the leaf lamina, between 10 a.m. and 4 p.m. The corresponding increase in reducing sugar was smaller and not significant. The average changes during the day in the sugar content of the petiole were almost the same as those of the leaf lamina, but were not significant. There was no indication of any diurnal variation in the root.

Later sowing caused an increase in the reducing sugar content and, to a less extent, in the sucrose content of the leaf lamina, in the later stages of growth. The reducing sugar content of the petiole was similarly affected, but the sucrose content of petiole and root was always depressed by later sowing. The reducing sugar content of the root was also slightly decreased. These results suggest that the effect of later sowing, previously demonstrated, in increasing the size and weight of the leaves, was caused by a restriction of the movement of carbohydrate out of the leaf, rather than by an increased ability of the leaf to utilize assimilate in growth.

Later sowing depressed the total yield per acre of sucrose in the root.

V. F. J. RICHARDS. "*Physiological Studies in Plant Nutrition. VIII. The Relation of Respiration Rate to the Carbohydrate and Nitrogen Metabolism of the Barley Leaf as Determined by Phosphorus and Potassium Supply.*" Annals of Botany, 1938, New Series, Vol II, pp. 491-534.

Barley was grown in sand culture at three levels of phosphorus nutrition. In three other series phosphorus and potassium were reduced proportionately.

Very considerable treatment differences were obtained in growth rate, final yield and weight of corresponding leaves ; these being almost entirely due to phosphorus and nearly independent of variation in potassium supply at any one phosphorus level.

Water content differences were comparatively slight.

Changes in respiration rate undergone during the first few hours in the dark are described and the results of Gregory and Sen (1937) confirmed.

Respiration rate was greatly reduced by phosphorus deficiency, the change with supply being greatest at comparatively high levels. When phosphorus and potassium were simultaneously proportionally reduced, the fall in respiration was at first more gradual than when phosphorus alone was altered, but at lower levels the resultant change was greater.

Progressive phosphorus deficiency led to progressive reduction in protein content and progressive and considerable increase in amino nitrogen.

Total sugars and sucrose were in general reduced by phosphorus deficiency, while reducing sugar was increased.

Respiration was generally closely related to nitrogenous substances in the series with high potassium and phosphorus supply. As the level of phosphorus supply falls the content of reducing sugar becomes of increasing importance which is interpreted as evidence for hexose as substrate and the importance of phosphate for its breakdown.

VI. W. E. BRENCHLEY. "*Comparative Effects of Cobalt, Nickel and Copper on Plant Growth.*" Annals of Applied Biology, 1938, Vol. XXV, pp. 671-694.

A general review is given of the distribution and the physiological importance of nickel and cobalt, in relation to plants and animals.

Experiments on barley and broad beans were carried out in water cultures with the sulphates and chlorides of cobalt, nickel and copper. In every case a range of low concentrations did little or no damage, but toxic action occurred abruptly above a concentration which varied with the species and with the compound. With barley, copper was the most poisonous element in either compound, but the differences were not striking. Low concentrations of the sulphate were inocuous, but parallel low strengths of the chloride caused a slight significant depression in growth. With broad beans, cobalt was much more poisonous than either nickel or copper, particularly with the sulphate. No slight depression with low concentrations of the chloride was noticeable with this species.

The morphological response to toxicity varied with the element concerned. Copper, in poisonous strengths, caused shortening and " bunching " of barley roots, whereas nickel and cobalt permitted the growth of elongated roots of a very attenuated nature. The individuality of plant response to poison was frequently shown by the great variation in growth in the borderline concentrations just below those which caused marked depression of growth.

(*b*) ACTION OF MANURES

VII. H. H. MANN. "*The Weed Herbage of a Slightly Acid Arable Soil.*" Journal of Ecology, 1939, Vol. XXVII, pp. 89-113.

The weed herbage was studied on a light sandy loam of slightly acid character which has been under continuous wheat or barley cropping for over fifty years. The several plots had various manurial treatments to 1926 and no manures since that date. A fallow taken in 1934 and 1935 enabled the general character of the weeds to be determined during the season.

With most of the important annual weeds in the soil, roughly half the year's growth of plants germinated before the end of April. This does not apply to individual weeds as the dominant one (*Spergula arvensis*) germinates at any time in the year, while some of the others, notably *Polygonum aviculare* (March to May), *Gnaphalium uliginosum* (June to September) and *Chenopodium album* (May and June) were very seasonal.

A single year's fallow, even when accompanied by frequent cultivations, is not very effective in getting rid of the annual weeds. Two years' fallow brings about, however, a fairly large reduction, except with *Stellaria media* and *Poa annua*, neither of which appeared to be appreciably altered in amount.

Acidity of the soil induced by previous manuring with sulphate of ammonia, had a very great influence on the weed herbage, and when the pH value was lower than 5.0, the annual plants consisted almost entirely of *Spergula arvensis*, with a small amount of *Polygonum aviculare* and *Poa annua*. *Matricaria inodora*, though an acid loving weed, disappeared almost entirely when the pH value was less than 5.4, but was also reduced in amount when the pH value was greater than 5.8. *Polygonum aviculare* and *Poa annua* are by far the least sensitive to changes in acidity of all that were found on the plots studied.

The effect of long continued application of mineral manures was very small on the number of plants per unit area, except in the case of *Vicia hirsuta*, which appeared as a serious weed only in the plots which had received mineral manures or farmyard manure, and then only when the pH value was over 5.6. The annual addition of farmyard manure for fifty years left a legacy of an increased amount of most of the weeds.

The effect of lime on the weed herbage is almost entirely governed by the change in acidity thereby induced. The lime did not appear to have a specific effect on any of the annual weeds examined.

The perennial weeds which tended to take possession of the plots were two "twitches," namely *Holcus mollis* and *Agrostis stolonifera*, which became serious in the more acid plots, while the more usual twitch (*Agropyrum repens*) was wholly absent in this sandy acid land. *Rumex acetosella* was common on the more acid plots and could not be got rid of even by a two years' fallow. *Equisetum arvense* occurred largely, though there was no sign of wetness anywhere in the field, and seemed to be rather encouraged by the fallowing of the land. *Convolvulus arvensis* only occurred in plots which had had mineral manures or farmyard manure in the previous half century, but its amount was hardly affected by even a two years' fallow.

VIII. J. T. MARTIN, H. H. MANN and F. TATTERSFIELD. "*The Manurial Requirements of Pyrethrum* (Chrysanthemum cinerariaefolium Trev.)." Annals of Applied Biology, 1939, Vol. XXVI, pp. 14-24.

A small field experiment upon the manurial requirements of the insecticidal pyrethrum plant, grown upon sandy soil of low fertility, is described. Lime had the effect of producing slight, but not significant, increases each year in the yield of flowers and their content of the pyrethrins, and decreased the percentages of plant failures in the fourth and fifth years of the experiment. There was a significant depression in the yield of flowers in the year after the single application of double dressings of the manures, but no effect in later years. The yearly application of moderate dressings of manures gave significant increases in the yield of flowers in the second and fifth years, and significant increases in the pyrethrin I content of the flowers in the fourth and fifth years of the experiment.

IX. H. H. MANN. "*Investigations on Clover Sickness.*" Journal of Agricultural Science, 1938, Vol. XXVIII, pp. 437-455.

If a clover sick soil be defined as one on which a normal crop of clover cannot be grown, but on which only small dwarfed plants are produced, the clover sickness can be found in the absence of the usual fungi to which it has been attributed, and also in the absence of the eelworm (*Anguillulina dipsaci*) which generally accompanies it.

In the particular soil examined, no manuring with lime, potash, or phosphates, or with easily available nitrogen in the form of potassium nitrate had any considerable effect in enabling good growth of clover to be obtained. Two methods, however, were capable of temporarily giving good crops. The first was the heating of the moist soil to a temperature of 60 to 70° C. for 1 to 2 hours. The effect of this treatment, however, passed off in a few months after one or two crops of clover had been obtained. The second method was the application of a very large dressing of farmyard manure. This was at first quite effective, but the quantity needed was not such as could be used in practice. Where nearly 10 per cent. of the weight of the soil was added in the form of wet farmyard manure, the effect continued even after four successive crops of clover had been grown: where 3 per cent. of the soil weight was added, the benefit very rapidly passed away after the second crop.

X. E. M. CROWTHER and R. G. WARREN. "*Report on Pot Culture, Laboratory Work and Other Investigations.*" Appendix I to the Fifteenth Report of the Permanent Committee on Basic Slag, Ministry of Agriculture, 1937, pp. 4-11.

In pot cultures four types of basic slag were compared for perennial ryegrass and turnips on an acid Scottish soil and on a neutral sand-bentonite mixture with two depths of incorporation of the basic slags. The turnips in spite of damage by pests responded to slags on both soils. but the rye-grass responded only on the artificial soil. The fact that rye-grass grew well on a soil on which turnips had failed completely from phosphate shortage in the field in the previous season suggests that some of the poor residual effects observed in field experiments are due to the ability of other crops to utilise soil phosphates which are not available to swedes. In the pot experiments in the soil but not in the sand the turnips gave better results when the slags were concentrated in a narrow band than when they were distributed more diffusely.

In conjunction with the Forestry Commission two experiments were laid down on young trees in Scotland to test three rates of application of three slags and mineral phosphate.

XI. E. M. CROWTHER and R. G. WARREN. "*Report on Pot Culture, Laboratory Work and Other Investigations*, 1937." Appendix I to the Sixteenth Interim Report of the Permanent Committee on Basic Slag, Ministry of Agriculture, 1939, pp. 4-9.

The pot experiments of the previous year were continued with clover, perennial rye-grass and timothy. In the sand cultures, from which about half of the citric soluble phosphoric acid of the slags had been removed in the previous year's crops, the clover failed and the two grasses did not grow well. In the soil all three crops grew well but the responses to basic slag residues were so small that it was not possible to differentiate between slags or between the responsiveness of the different crops.

Laboratory extractions under controlled pH values brought out the unexpected result that the relative solubilities of two medium soluble slags were different in citric acid and in other acids at the same pH value.

XII. E. M. CROWTHER (with D. N. MCARTHER). "*Report on Field Experiments in* 1936." Appendix II to Fifteenth Interim Report of the Permanent Committee on Basic Slag, Ministry of Agriculture, 1937, pp. 12-22.

Four field experiments were conducted on swedes to compare two rates of application of three less soluble types of slag with four rates of application of a high-soluble slag. The yields from the less soluble slags were generally similar to those from high soluble slag supplying equal amounts of citric-soluble phosphoric acid. The phosphoric acid contents of the dry swedes were increased considerably by the higher rates of application of the more soluble slags and this allowed comparisons of the slags to be made over a much wider range than was possible from the yields alone.

XIII. E. M. CROWTHER (with D. N. MCARTHER). "*Report on Field Experiments in* 1937." Appendix II to the Sixteenth Interim Report of the Permanent Committee on Basic Slag, Ministry of Agriculture, 1939, pp. 10-22.

Five experiments similar to those of 1936 again gave very steep response curves to basic slag, one-eighth of the customary dressing of high-soluble slag doubling the yield of swedes. Such results emphasise the importance of working well below the upper limit of yield in comparing the availabilities of different slags. The results were generally related to the amounts of citric soluble phosphoric acid supplied, except that those from the more soluble of the two medium-soluble slags were definitely better than would have been expected on this basis. This failure of the citric acid method was far more striking than in any of the three preceding years.

STATISTICAL METHODS AND RESULTS

(Department of Statistics; and Field Experiments Section)

(a) THEORETICAL

XIV. F. YATES. "*An Apparent Inconsistency Arising from Tests of Significance Based on Fiducial Distributions of Unknown Parameters.*" Proceedings of the Cambridge Philosophical Society, 1939, Vol. XXXV, Part IV.

The problem of testing whether the means of two samples are significantly different, when there is no reason to suppose that the variances of the observations on which the means are based are equal, presents certain features which do not arise in other tests of significance.

Behrens and Fisher have proposed an exact test based on the fiducial distribution of the ratio of the variances of the two sets of observations, which at first sight appears to give rise to certain inconsistencies. The cause of these apparent anomalies is explained and it is shown that the criticisms based on them are invalid, being due to (*a*) neglect of the relevant information provided by the estimated values of the variances, and (*b*) an insufficient appreciation of the fiducial basis of all tests of significance (including the ordinary t-test) on small samples.

The problem of testing the weighted mean of the means of two sets of observations concerning whose relative accuracy no prior knowledge is available is shown to be similar to that of testing the difference of the means of two samples.

XV. F. YATES. "*Tests of Significance of the Differences between Regression Coefficients Derived from Two Sets of Correlated Variates.*" Proceedings of the Royal Society of Edinburgh, 1939, Vol. LIX, pp. 184-194.

Tests of significance of the differences of regression coefficients derived from two sets of correlated dependent and independent variates are described. The necessary computations are reduced to a systematic and easily calculable form, and are illustrated by a numerical example.

XVI. F. YATES. "*Orthogonal Functions and Tests of Significance in the Analysis of Variance.*" Supplement to the Journal of the Royal Statistical Society, 1938, Vol. V, pp. 177-180.

In many types of statistical analysis based on the method of least squares, it is necessary to test the significance of one group of effects while admitting the possible existence of other groups of effects.

In the present paper explicit proof is given of the procedure adopted for such tests of significance. The general properties of orthogonal functions are also described.

XVII. F. YATES. "*The Adjustment of the Weights of Compound Index Numbers Based on Inaccurate Data.*" Journal of the Royal Statistical Society, 1939, Vol. CII, pp. 285-288.

The problem of choosing the weights of the components of compound index numbers based on inaccurate data is discussed. It is shown that a process analogous to that adopted for the formation of a discriminant function will give the set of index numbers agreeing most closely with the entities they are intended to represent.

XVIII. W. G. COCHRAN. "*The Omission or Addition of an Independent Variate in Multiple Linear Regression.*" Supplement to the Journal of the Royal Statistical Society, 1938, Vol. V, pp. 171-176.

If tests of significance of the regression coefficients are required in a multiple regression, the normal equations are usually best solved by finding first the components c_{pq} of the inverse matrix. When it is desired to omit or to add one or more independent variates after the original regression equations have been solved, the new c's and regression coefficients may easily be calculated from the original c's and regression co-efficients. A numerical example of the addition of an independent variate is given to illustrate the computations.

XIX. W. G. COCHRAN. "*An Extension of Gold's Method of Examining the Apparent Persistence of One Type of Weather.*" Quarterly Journal of the Royal Meteorological Society, 1938, Vol. LXIV, pp. 631-634.

If a meteorological event is classified into two types only, for instance wet or dry months, a tendency towards persistence of the same type of weather may be tested by examining the distribution of lengths of runs of the same type. Gold's formula for the expected number of runs of length *r* from *m* events is extended to the case in which the probabilities of the two events are unequal. A simple test of significance of persistence is found by classifying the data in a 2 × 2 contingency table, according to the results at the current and previous trials.

(*b*) DESIGN AND ANALYSIS OF EXPERIMENTS

XX. F. YATES. "*The Recovery of Inter-block Information in Variety Trials Arranged in Three Dimensional Lattices.*" Annals of Eugenics, 1939, Vol. IX, pp. 136-156.

The quasi-factorial and incomplete block designs, as originally put forward, although in general considerably more efficient than designs involving the use of controls, had the defect of being *less* efficient than ordinary randomized blocks if the reduction in variability resulting from the use of the smaller blocks was in fact small. This was a consequence of the fact that certain of the varietal (or treatment) comparisons were confounded with block differences, and the information contained in the inter-block comparisons was wholly discarded.

In the present paper an account is given of the method of estimating the relative accuracy of these comparisons, and of recovering the information contained in them. Only the case of the three dimensional lattice is discussed here. It is proposed to deal with the other types of design in subsequent papers.

The procedure consists of so arranging the analysis of variance that an estimate of the inter-block variance is provided, freed from varietal effects, and then calculating adjustments to the varietal means such that the inter and intra-block comparisons are correctly weighted according to their relative accuracy.

The computations are fully illustrated by a numerical example. It is shown that the amount of computation required for the full analysis is scarcely greater than that required for the complete elimination of block effects, which was the method of analysis originally proposed.

With this modification the efficiency of these designs is shown to be always greater than that of ordinary randomized blocks, except for the limiting case when there is no reduction of variance due to the use of the smaller blocks: in this case a small amount of information is lost due to inaccuracies of weighting, but in general this loss is quite trivial.

It is also pointed out that it is quite legitimate to analyse the results of a quasi-factorial experiment as if it were an experiment arranged in ordinary randomized blocks. This is a valuable property of the designs, since it enables subsidiary measurements which are unlikely to be much affected by block differences, or for which high accuracy is not required, to be abstracted with a minimum of computation.

XXI. F. YATES. "*The Comparative Advantages of Systematic and Randomized Arrangements in the Design of Agricultural and Biological Experiments.*" Biometrika, 1939, Vol. XXX, pp. 440-469.

The recent claims advanced in favour of systematic arrangements by Gosset (" Student ") and others are examined. The conclusion is reached that in cases where Latin square designs can be used, and in many cases where randomized blocks have to be employed, the gain in accuracy with systematic arrangements is not likely to be sufficiently great to outweigh the disadvantages to which systematic designs are subject. In particular the available evidence, though not conclusive, indicates that the half-drill strip arrangement, which Gosset particularly favoured, is likely to be somewhat less accurate than suitable random arrangements occupying the same plots. On the other hand, systematic arrangements may in certain cases give decidedly greater accuracy than randomized blocks, but it appears that in such cases the use of the modern devices of confounding, quasi-factorial designs, or split plot Latin squares, which are much more satisfactory statistically, are likely to give a similar gain in accuracy.

As an example the uniformity trial chosen by Barbacki and Fisher to demonstrate the defects of the half-drill strip arrangement is re-examined. It is shown that Gosset's criticisms of Barbacki and Fisher's work, though at first sight convincing, are not as conclusive as he supposed, and that in fact this particular trial provides a striking example of just those defects which have always been attributed to the half-drill strip method by its critics.

XXII. F. YATES and R. W. HALE. "*The Analysis of Latin Squares when Two or more Rows, Columns, or Treatments are Missing.*" Supplement to the Journal of the Royal Statistical Society, 1939, Vol. VI, pp. 67-79.

Methods of analysing a Latin square with two or more missing treatments, rows or columns are described, and illustrated by an example.

Attention is drawn to a special type of incomplete square, introduced by Youden, which is capable of simple analysis. Youden squares provide valid experimental arrangements, which are likely to be of value in biological experiments and occasionally in variety trials.

The evaluation of the reciprocal matrix when redundant constants or regression coefficients are introduced into least square solutions is also discussed.

XXIII. W. G. COCHRAN. "*Long-term Agricultural Experiments.*" Supplement to the Journal of the Royal Statistical Society, 1939, Vol. VI, Part II.

The various types of long-term experiment are described. The design of experiments on a single crop or on a fixed rotation of crops with fixed treatments is discussed and the statistical analyses are illustrated by numerical examples. Where treatments are applied at fixed intervals only, the residual as well as the direct effects can be assessed. The possibility of obtaining greatly increased accuracy on the residual effects by ensuring that the periods of the crops and treatment cycles are different is pointed out. The method of separating the direct and residual effects when the treatments rotate from plot to plot in successive years is examined and illustrated by a numerical example. The design of long-term experiments on the effects of different crop sequences and the advisability of including indicator crops are discussed. In conclusion, some practical considerations of importance are mentioned.

(*c*) ANALYSIS OF DATA

XXIV. F. YATES and D. J. WATSON. "*Factors Influencing the Percentage of Nitrogen in the Barley Grain of Hoosfield.*" Journal of Agricultural Science, 1939, Vol. XXIX, pp. 452-458.

The effect of rainfall, sowing date and yield on the percentage of nitrogen in the barley grain of certain representative plots on Hoosfield is studied.

All these factors are shown to have marked effects. The farmyard manure plot differs from the others, both in mean percentage and in the effects of rainfall and yield.

Changes in variety appear to have had little influence, but there is a progressive decrease in the percentage of nitrogen which cannot be accounted for by changes in any of the above factors.

Comparison is made with the results of the similar study on the permanent barley plots at Woburn.

XXV. D. A. BOYD. "*Correlations Between Monthly Rainfall at Eleven Stations in the British Isles.*" Memoirs of the Royal Meteorological Society, 1939, Vol. IV, pp. 143-156.

The paper is based upon rainfall records for the months of January, April, July and October at eleven stations in the British Isles over the period 1870-1929.

The means, variances and covariances were computed. Percentage standard errors were obtained and mapped, the distribution proving similar in all months.

A correlation coefficient for each pair of stations in each of the chosen months was evaluated, and transformed to z. The value of z was dependent to a considerable extent on the inter-station distance and bearing. The linear regression of z on distance between stations was significant in each month, but the quadratic term was small and non-significant. The remaining two terms of the regression, associated with the bearing between pairs of stations, reached significance on only two occasions out of the possible eight ; but, as a whole, they gave a reasonably coherent picture of monthly changes in the inter-station bearing at which correlation reached a maximum.

To account for such changes, and for changes in $\bar{z}$, data given by other workers were examined. The variations appeared to be closely associated with the persistence of a pressure gradient for winds from the south-westerly quadrant.

A large part of the residual variance is shown to be due to a marked regional variation, the association between monthly rainfalls being greatest in the south and least in the north. Maps of the residual z's show that the association within groups of stations on the west coast or on the east coast was greater than that between the west and east coast groups.

XXVI. D. A. BOYD. " *The Estimation of Rothamsted Temperature from the Temperature of Oxford and Greenwich.*" Annals of Eugenics, 1939, Vol. IX, pp. 341-353.

It is proposed shortly to analyse the effect of temperature on the Rothamsted crop-yields. For this purpose the mean temperature Q_0 for each crop year is required, and also quantities $Q_1 \ldots Q_5$ proportional to the regression coefficients of a fifth degree polynomial fitted to the weekly mean temperature of each crop year. Rothamsted's temperature record did not commence until 1878, whereas yields for most of the classical experiments are available from 1852. The possibility of estimating the required values from the longer records of Oxford and Greenwich for the period 1852-3 to 1877-8 has therefore been investigated.

As a first step, the quantities Q were evaluated for a period of years (1878-9 to 1907-8) during which the three stations were concurrent, and the means, variances and covariances of each set of Q's were calculated. Greenwich appears to have had a slightly more extreme climate than Oxford or Rothamsted, but this may have been due in part to the unorthodox exposure of the thermometers there. A significant increase in mean temperature over the period was noted, amounting to about 0.05°F. a year. Changes in the seasonal distribution of temperature were not significant. The variance of Rothamsted temperature was significantly smaller than that of Oxford or Greenwich, both from week to week, and from year to year. This noteworthy difference was doubtless due to the more upland situation of Rothamsted.

The linear regressions of the Q's for Rothamsted on the corresponding values for Oxford and Greenwich were evaluated, taking the two stations individually and simultaneously. Oxford gave a better fit than Greenwich in every case, and the partial regression on the two stations was little better than the regression on Oxford alone. The fit was very good for the regression of Rothamsted on Oxford, the residual variance in no case exceeding 5 per cent.

Very satisfactory estimates of the mean annual temperature and of the regression coefficients up to the 5th degree may therefore be obtained for Rothamsted from the temperature records of Oxford only. At the same time differences of surprising magnitude have been revealed in the variability of weekly and annual temperature at Rothamsted as compared with Oxford and Greenwich.

(*d*) SAMPLING

XXVII. W. G. COCHRAN. " *The Use of the Analysis of Variance in Enumeration by Sampling.*" Journal of the American Statistical Association, 1939, Vol. XXIV, pp. 492-510.

The results of a properly planned sampling investigation, in addition to providing an estimate of the accuracy of the method, often give estimates of the accuracy of various alternative methods of sampling which might have been used. These estimates are helpful in increasing the efficiency of sampling in future studies on similar material. The use of the analysis of variance of the sampling results for this purpose is discussed and illustrated by a numerical example. The case in which an appreciable fraction, say, more than 10 per cent., of the total population is sampled is discussed briefly. The estimate of the relative accuracy of two methods of sampling is shown to be in most cases a simple function of the variance ratio, so that its sampling limits are easily obtainable. Some advice is given on the problem of analysing the results of large samples without excessive labour.

XXVIII. W. G. Cochran. "*The Information Supplied by the Sampling Results.*" (Appendix to a paper by W. R. S. Ladell). Annals of Applied Biology, 1938, Vol. XXV, pp. 383-389.

In any field experiment which involves sampling of a laborious nature, it is important to know as soon as possible what degree of accuracy in the treatment mean values will be reached with a given amount of work, how much work must be done to reach a given standard of accuracy and how best to distribute one's resources between the amount of sampling and the amount of replication.

The first sampling, whether it contains experimental treatments or is uniformly treated, can supply information on all these points if properly carried out. Ladell's first wireworm sampling is taken as a simple numerical example of the way in which these questions can be answered with the help of an analysis of variance.

The sampling and experimental errors of Ladell's experiments are discussed. The sampling error accounts for a large proportion of the experimental error in most cases, as it is always advisable where the labour involved in sampling is high.

Ladell's sampling errors agree well with those obtained under widely different conditions by Jones, and both may be recommended to other workers as an indication of the amount of variability to be expected in field sampling for wireworms.

XXIX. W. G. Cochran. "*Expected Errors in Diluting Bacterial Suspensions.*" (Appendix to a paper by H. L. A. Tarr). Annals of Applied Biology, 1938, Vol. XXV, pp. 633-643.

A knowledge of the amount of variation introduced by the process of dilution in the number of spores or vegetative cells in a solution is often of interest to bacteriological workers. The variations introduced by diluting consist of two parts (1) a sampling error, which with careful work will tend to follow a Poisson series distribution (2) the error involved in extracting rather more or less than the volume of liquid stated on the pipette. By making reasonable assumptions about the second source of error, standard errors and 5 per cent. limits of variation can be assigned to the number of spores or vegetative cells in the volume which is being used for experimental purposes. A table of these errors and limits is given, covering the range from 10^6 to 10 spores per unit volume. Examples of its use are worked out.

THE SOIL

(Departments of Chemistry and Physics)

XXX. G. Nagelschmidt. "*On the Atomic Arrangement and Variability of the Montmorillonite Group.*" Mineralogical Magazine, 1938, Vol. XXV, pp. 140-155.

A classification of clay minerals is based on their lattice structures and the quality of their X-ray powder diagrams. The montmorillonite group, with a three layer lattice and poor powder diagrams, is shown to have three end-members, which in the completely dehydrated state and free from isomorphous replacements are montmorillonite $Al_2Si_4O_{11}$, nontronite $Fe_2Si_4O_{11}$ and magnesium beidellite $Mg_3Si_4O_{11}$. Calculations of the isomorphous replacements for six of these materials showed that the excess cations balanced the negative charges resulting from the replacements. Further it was shown that for three of these materials all the excess cations were exchangeable, though there were discrepancies with magnesium beidellite.

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The hypothesis is advanced that a certain amount of isomorphous replacement of silicon by aluminium and perhaps of aluminium by magnesium is essential for this structural type. This may explain both the high water content, which is due to the excess cations, and the poor diffracting power for X-rays, which is due to the lack of regularity in the lattice.

X-ray powder data for the six samples and the values for the lattice shrinkage upon dehydration are given and discussed.

XXXI. E. W. RUSSELL. "*Soil Structure*." Imperial Bureau of Soil Science, Technical Communication No. 37, 1938. Price 2s.

The problems concerned with the production and maintenance of a good soil structure, which is a fundamental element in good tilth, have been extensively investigated during the last few years. This review describes the many methods that have been devised for measuring the soil structure quantitatively, the degree of control that can be obtained over the soil structure by weathering, cultivation, the application of manures and the growing crops and the theories that have been put forward to explain the results.

XXXII. R. K. SCHOFIELD. "*Pore-Size Distribution as Revealed by the Dependence of Suction (pF) on Moisture Content*." Transactions of the First Commission of the International Society of Soil Science, 1938, Vol. A, pp. 38-45.

By following the invasion of air into the pores of soil samples as the pF rises and its replacement by water as the pF falls a measure is obtained of the pore-size distribution.

When the suction does not exceed pF 6 (50 per cent. R.H.) there are good reasons for believing that results of the right order of magnitude are obtained by assuming the normal value for the surface tension.

Above pF 6 the direct adhesion of the water molecules to the solid surfaces and to the hydration of the exchangeable ions are probably the controlling factors.

XXXIII. B. A. KEEN. "*What Happens to the Rain ?*" Quarterly Journal of the Royal Meteorological Society, 1939, Vol. LXV, pp. 123-137.

An annual rainfall of 30 in. means that 3,000 tons of water fall on an acre of land. In the course of the year this all disappears, by run-off, evaporation, transpiration through vegetation, and by downward percolation. The relative importance of these factors in British and overseas conditions is discussed. Many of the traditional beliefs among farmers and gardeners were based on a theory of water movement that was attractively simple to understand—but incorrect. It is only in recent years that the true picture of the movement of water in the soil has been built up. In consequence, some of the traditional practices need revision, while others now have a different explanation. The new work has also clarified some of the concepts used in hydrology.

XXXIV. R. K. SCHOFIELD. "*The Representation of Soil Colour by Means of the C.I.E. Co-ordinates*." Transactions of the First Commission of the International Society of Soil Science, 1938, Vol. A, pp. 54-59.

The way in which C.I.E. colour co-ordinates can be computed from the Maxwell spinning disk is explained.

A numerical example is worked out in detail by way of illustration, the hue wave-length, the purity and the relative brightness being also evaluated.

The cause of the differences in the matches obtained between soils and Munsell colour disks by different observers is explained, and it is concluded that such matches obtained by observers of unknown visual characteristics do not provide a satisfactory basis for soil colour nomenclature.

Various ways are discussed in which better results might be obtained.

MICROBIOLOGY

(Departments of Fermentation and General Microbiology)

XXXV. E. H. RICHARDS. "*Note on the Effect of Temperature on a Mixed Culture of Two Organisms in Symbiotic Relation.*" Journal of Agricultural Science, 1939, Vol. XXIX, pp. 302-305.

A study was made of nitrogen-fixation by *Azotobacter chroococcum* alone in a medium containing dextrose (which it can utilize) and in mixture with a coliform organism on a medium containing no carbohydrate except starch, which *Azotobacter* cannot utilize unless it be hydrolysed by the coliform organism or some other agency.

The amount of nitrogen fixed in the mixed cultures was found to be maximal at two temperatures, and a discussion is given of the causes thought to be operative in producing the double maximum.

XXXVI. A. DIXON. "*The Protozoa of some East Greenland Soils.*" Journal of Animal Ecology, 1939, Vol. VIII, pp. 162-167.

Soil samples from Kangerdlgussuak in East Greenland were examined. A large protozoan population was present even in those which were frozen for nine months of the year, the greatest number of species being found in the soils producing the richest vegetation. The testaceous Rhizopods in these soils were unusually numerous in some of the non-peaty samples.

THE PLANT IN DISEASE: CONTROL OF DISEASE

(Departments of Entomology, Insecticides and Fungicides, and Plant Pathology)

(*a*) INSECTS AND THEIR CONTROL

XXXVII. C. B. WILLIAMS. "*The Migration of Butterflies in India.*" Journal of the Bombay Natural History Society, 1938, Vol. XL, pp. 439-457.

This account of the known migrations of butterflies of India was written at the request of the Bombay Natural History Society to stimulate interest in the subject in India. About eighty records relating to 52 species are discussed and tabulated. A map shows the localities where flights have been seen. The species migrating on the slopes of the Himalayas in North India are different from those migrating further south on the plains. The species migrating in South India are, however, very similar to those in Ceylon. There is some evidence of the flight seasons being related to the seasonal temperature changes in the north, and to the monsoon changes in the south.

XXXVIII. C. B. WILLIAMS. "*Recent Progress in the Study of Some North American Migrant Butterflies.*" Annals of the Entomological Society of America, 1938, Vol. XXXI, pp. 211-239.

This is a summary and discussion of a number of new records of migration of butterflies in North America and particularly of the Monarch (*Danaus plexippus*), the Painted Lady (*Vanessa cardui*), and the Migratory Sulphur (*Phoebis eubule*). In the former southward autumn flights are found in the Eastern States down to Florida and in the Central Plains from the Great Lakes down to Texas. In the mountain areas there are no flights, but they are again found on the Pacific coast. In the Painted Lady invasions occur in the spring from the south apparently only from the arid portions of Western Mexico. Great immigrations occurred in 1924, 1926, 1931 and 1935 but none in the intervening years. For *Phoebis eubule* there is given a remarkable series of observations by Mr. P. Smyth lasting over eighteen consecutive years. Other species are also discussed.

XXXIX. K. J. FISHER (K. J. GRANT). "*Migrations of the Silver-Y Moth* (Plusia gamma) *in Great Britain.*" Journal of Animal Ecology, 1938, Vol. VII, pp. 230-247.

An account of immigrations of the Silver-Y moth from 1932-1936. The flights in the last of these years was on a very extended scale and considerable damage was done by the larvae. The moth was seen as far north as the Shetland Islands. The first immigrants were seen on May 6th, but the main immigration was in June. The data are analysed and show considerable evidence to support a return flight to the south in the autumn. The wind has no apparent influence on the direction of flight.

XL. D. C. THOMAS. "*Report on the Hemiptera-Heteroptera taken in the Light Trap at Rothamsted Experimental Station, During the Four Years* 1933-1936." Proceedings of the Royal Entomological Society of London, A, 1938. Vol. XIII, pp. 19-24.

Seventy-four species of Heteroptera were identified of which 57 were of the family Capsidae. This latter number is about one-third of the known British species of Capsidae. Several species captured were new to the district. The Capsidae were predominantly males, and the Corixidae chiefly females.

XLI. B. LOVIBOND. "*The Fever Fly* Dilophus febrilis *L.*" Journal of the Board of Greenkeeping Research, 1938, Vol. V, pp. 271-273.

Fever fly grubs are frequently found in clusters on golf greens and are often confused with leather jackets. The damage consists of thin patches round the nests and loosening of the soil. The life history has been thoroughly investigated by other workers and is quite straightforward, there being two generations in the year. Lead arsenate has given good control.

XLII. B. LOVIBOND. "Meloe proscarabaeus *L.*" Journal of the Board of Greenkeeping Research, 1939, Vol. VI, pp. 42-45.

Specimens of the oil beetle *Meloe proscarabaeus* L. were troublesome on a Lancashire golf course but did not cause any actual damage to the turf. It was found that they mated and laid eggs readily under laboratory conditions. An excellent hatch was obtained but as the triungulins could not be persuaded to feed, it was impossible to carry them on to the adult stage.

XLIII. K. N. TREHAN. "*Two New Species of Aleurodidae Found on Ferns in Greenhouses in Britain.*" Proceedings of the Royal Entomological Society of London, B, 1938 Vol. VII, pp. 182-189.

Two new Whiteflies were found on ferns in the Fernhouse at the Royal Botanic Gardens at Kew. They are described as *Aleuroplatus kewensis* and *Trialeurodes williamsi*.

XLIV. A. C. EVANS. "*Studies on the Distribution of Nitrogen in Insects.*" *I. In the Castes of the Wasp,* Vespula germanica (*Fab.*)." Proceedings of the Royal Entomological Society of London, A, 1938, Vol. XIII, pp. 25-29.

In the adult wasp most of the nitrogen is present in the cuticle and soluble protein fractions, in prepupae little is found in the cuticle, but over 60 per cent. is in the form of soluble protein. Just emerged wasps probably contain a reserve protein, insoluble in water, which is utilised to complete the hardening of the cuticle. The fat-body of queens preparing for hibernation weighs about 25 per cent. of the body-weight and contains about 1.3 per cent. of nitrogen.

XLV. A. C. EVANS. "*Studies on the Distribution of Nitrogen in Insects. II. A Note on the Estimation and Some Properties of Insect Cuticle.*" Proceedings of the Royal Entomological Society of London, A, 1938, Vol. XIII, pp. 107-110.

The cuticle of *Tenebrio molitor* L. contains about 60 per cent. protein which is soluble in dilute acids and alkalis. The hypothesis is put forward that part of the material absorbed from the cuticle at the last larval moult may eventually be utilised to form the major part of the adult cuticle.

XLVI. A. C. EVANS. "*Physiological Relationships between Insects and their Host Plants. I. The Effect of the Chemical Composition of the Plant on Reproduction and Production of Winged Forms in* Brevicoryne brassicae *L.* (*Aphididae.*")) Annals of Applied Biology, 1938, Vol. XXV, pp. 558-572.

Under late summer conditions of light the rate of reproduction of the aphis *Brevicoryne brassicae* is positively correlated with the nitrogen content of the host plant and, in particular, with the protein content. The formation of winged forms is negatively correlated with the same factors.

XLVII. W. R. S. LADELL. "*Field Experiments on the Control of Wireworms.*" with an Appendix by W. G. Cochran. Annals of Applied Biology, 1938, Vol. XXV, pp. 341-389.

An account is given of three field experiments planned to show the effect of soil insecticides on wireworms. One was in the form of a 5 x 5 latin square; the other two 3 x 10 and 6 x 8 randomised blocks. The mean density of wireworms before control was 65, 335 and 277 per square yard respectively. Distribution was uneven and thus introduced high sampling errors. Several fumigants showed significant reductions in the population, one of the best being crude naphthalene.

XLVIII. F. TATTERSFIELD and J. T. MARTIN. "*The Problem of the Evaluation of Rotenone-containing Plants. IV. The Toxicity to* Aphis rumicis *of Certain Products Isolated from Derris Root,*" with an Appendix by W. G. COCHRAN. Annals of Applied Biology, 1938, Vol. XXV, pp. 411-429.

An account is given of the preparation and a few of the properties of a compound isolated from the extracts of Sumatra-type derris root.

This compound yields optically inactive toxicarol in high yield, and is characterised by the switch-over from laevo- to dextro-rotation on the addition of caustic potash in methyl alcohol to its benzene solution, and is mainly responsible for this feature of the Sumatra-type resins under similar treatment. The change-over in rotation was followed by a gradual fall in rotation of a unimolecular type. The compound is laevo-rotatory in benzene and dextro-rotatory in alcohol.

The toxicities to *Aphis rumicis* of rotenone, toxicarol precursor, sumatrol, toxicarol and the residual resins from the Sumatra-type and *Derris elliptica* roots have been determined. In our experiments the toxicity in descending order was Rotenone > *D. elliptica* resin > Sumatra-type resin > sumatrol = toxicarol precursor > inactive toxicarol.

In the Appendix, the computations necessary to estimate the relative potencies of two insecticides from controlled experiments on insects are illustrated by a numerical example. A brief discussion is given of the appropriate tests of significance.

XLIX. J. T. MARTIN. "*The Chemical Evaluation of Pyrethrum Flowers* (Chrysanthemum cinerariaefolium)." Journal of Agricultural Science, 1938, Vol. XXVIII, pp. 456-471.

Comparative analyses of pyrethrum flowers have been carried out by the methods of Tattersfield, Seil, Ripert, Haller and Acree and Wilcoxon.

The methods were of value in indicating the relative richness in pyrethrins of the samples tested, but discrepancies were seen in the absolute values of the pyrethins I and II recorded. Under present conditions and until a standard method of analysis is agreed upon, it would appear requisite to state the method employed in the evaluation of the flowers.

The Wilcoxon method has given higher figures for the pyrethrin I content than the Seil method. The degree of divergence between the results depended upon the richness of the flowers, and upon the excess of acid used in distilling the volatile acid in the Seil method. The relationship between the amount of the pyrethrin I acid present and the titration recorded in the Wilcoxon method was not a linear one.

The question of the solvent to be used for the initial extraction of the flowers has been briefly discussed.

L. S. H. HARPER. "*A New Compound from* Derris elliptica *Resin.*" Chemistry and Industry, 1938, Vol. LVII, p. 1059.

By chromatographic absorption on alumina of a rotenone-free *D. elliptica* resin Buckley's compound is obtained. It has the formula $C_{20}H_{16}O_6$. A structure is assigned based on its similarity to *iso*-rotenone.

(*b*) FUNGUS DISEASES

LI. S. D. GARRETT. "*Soil Conditions and the Root-Infecting Fungi.*" Biological Reviews, 1938, Vol. XIII, pp. 159-185.

An examination is made of papers published during the last fifteen years on soil-borne fungus diseases of plants, with special reference to the influence of soil conditions on infection.

In reviewing the ecology of the root-infecting fungi, a distinction is drawn following Reinking, between *soil inhabitants* and *soil invaders*.

The *soil inhabitants* are considered to be primitive or unspecialised parasites with a wide host range; these fungi are distributed throughout the soil, and their parasitism appears to be incidental to their saprophytic existence as members of the general soil microflora.

The *soil invaders*, to which class the majority of the root-infecting fungi seem to belong, are more highly specialised parasites; the presence of such fungi in the soil is generally closely associated with that of their host plants. In the continued absence of host plant, such fungi die out in the soil, owing to their inability to compete with the soil saprophytes for an existence on non-living organic matter. This close association between the *soil invaders* and their host plants thus seems to be enforced by the competition of the general soil microflora.

The influence of soil conditions upon a number of soil-borne fungus diseases is tabulated and discussed under the headings of soil moisture content, texture, organic matter, reaction and chemical composition.

LII. S. D. GARRETT. "*Soil Conditions and the Take-all Disease of Wheat. III. Decomposition of the Resting Mycelium of* Ophiobolus graminis *in Infected Wheat Stubble Buried in the Soil.*" Annals of Applied Biology, 1938, Vol. XXV, pp. 742-766.

Decline in viability of the resting mycelium of *Ophiobolus graminis* in artificially infected wheat straw was followed under experimentally controlled soil conditions in glass tumblers. The results suggested that the disappearance of *Ophiobolus* from the straws was due to its natural decomposition by the other soil organisms, since, in its resting phase, the fungus tolerated adverse physical conditions of the soil better than those optimum for microbiological activity. The decline of *Ophiobolus* was hastened by the addition to the soil of energy materials poor or lacking in nitrogen, such as glucose, starch and rye-grass meal, whilst it was postponed by the addition of organic nitrogen in the form of dried blood, or of inorganic nitrogen, as ammonium carbonate. These results led to the hypothesis that the *Ophiobolus* mycelium is decomposed as a source of nitrogen by the micro-organisms engaged in breaking down the straw residues.

LIII. S. D. GARRETT. "*Soil Conditions and the Take-all Disease of Wheat IV. Factors Limiting Infection by Ascospores of* Ophiobolus graminis." Annals of Applied Biology, 1939, Vol. XXVI, pp. 47-55.

No infection of wheat seedlings by the ascospores of *Ophiobolus graminis* could be obtained except under strictly pure culture conditions in bacteriologically sterile soil or sand. Yet such ascospores germinated well on nutrient agar, and the resulting mycelial cultures would produce infection of wheat seedlings growing under natural soil conditions. Failure of the ascospores to cause infection under ordinary soil conditions was attributed to competitive assimilation by the other soil micro-organisms of the root excretions, which in sterile soils are wholly available to the germinating ascospores.

(*c*) VIRUS DISEASES

LIV. F. C. BAWDEN and N. W. PIRIE. "*Liquid Crystalline Preparations of Potato Virus 'X'.*" British Journal of Experimental Pathology, 1938, Vol. XIX, pp. 66-82.

Methods are described for the isolation of nucleoproteins from *N. tabacum*, *N. glutinosa* and *Lycopersicum esculentum*, infected with the S and G strains of potato virus "X." These have not been isolated from healthy plants, and the available evidence suggests that they are the viruses themselves. Infections were obtained with 10^{-9} gm., and specific serological reactions with $\frac{1}{6 \times 10^{6}}$ gm. Concentrated solutions are spontaneously bi-refringent and dilute solutions show anisotropy of flow; when sedimented by high-speed centrifugation the nucleoproteins form birefringent jellies, but when precipitated with acid or ammonium sulphate the material appears amorphous under the microscope.

The filterability of the virus after purification is less than that of the virus in untreated sap, and purification appears to cause the virus particles to aggregate into rods.

Two types of inactivation are described: one leads to a loss of infectivity without changing the optical properties or serological reactions, whereas the other denatures the protein and destroys all three. The effects of heating, drying, acid, alcohol, sodium dodecyl sulphate, irradiation with X-rays and ultra-violet light, and hydrogen peroxide are described. The properties of virus " X " are compared with those of tobacco mosaic virus, and the results discussed.

LV. F. C. Bawden and N. W. Pirie. "*Crystalline Preparations of Tomato Bushy Stunt Virus.*" British Journal of Experimental Pathology, 1938, Vol. XIX, pp. 251-263.

The isolation of a protein, probably the virus itself, is described from plants infected with tomato Bushy stunt virus. This protein not only differs from the normal plant proteins, but it also differs more from the other purified plant viruses than these differ from one another. It is fully crystalline instead of liquid crystalline. It has a higher nucleic acid content than tobacco mosaic virus or potato virus " X," and is more stable towards pH changes, but less stable towards dehydrating agents. Its particles are not elongated, and liquid and solid preparations are isotropic. 1 c.c. of solution containing 10^{-7} gm. produces infection when rubbed on to *N. glutinosa*, and 1 c.c. containing 10^{-6} gm. gives a specific precipitate with antiserum. Precipitates of the rod-shaped viruses with their antisera resemble those obtained with bacterial flagellar (" H ") antigens, but those of Bushy stunt virus resemble those with somatic (" O ") antigens. When irradiated with ultra-violet light or treated with nitrous acid the virus loses its infectivity, but it can still be crystallised and still retains its serological activity.

LVI. F. C. Bawden and N. W. Pirie. "*A Note on Some Protein Constituents of Normal Tobacco and Tomato Leaves.*" British Journal of Experimental Pathology, 1938, Vol. XIX, pp. 264-267.

Proteins with high molecular weights have been isolated from healthy tobacco and tomato plants. Except for their large size, these proteins have little in common with the plant viruses that have been purified. They contain 14-16 per cent. N., but less than 0.2 per cent.P and less than 1 per cent. carbohydrate, whereas the viruses are nucleoproteins.

LVII. F. C. Bawden and F. M. L. Sheffield. "*The Intracellular Inclusions of Some Plant Virus Diseases.*" Annals of Applied Biology, 1939, Vol. XXVI, pp. 102-115.

The contents of healthy cells and those infected with a number of different plant viruses are described. Some of these viruses apparently do not cause the production of intracellular inclusions; others cause the production of amorphous bodies only and the remainder produce both amorphous and crystalline inclusions. The properties of the inclusions are compared with those of purified preparations of the viruses. It is shown that insoluble complexes of the viruses with protamines, histones and proteins which in many ways resemble the intracellular inclusions can be produced *in vitro*. Possible explanations for the formation and disappearance of the inclusions in infected plants are suggested.

LVIII. F. M. L. SHEFFIELD. "*Vein Clearing and Vein Banding Induced by Hyoscyamus III Disease.*" Annals of Applied Biology, 1938, Vol. XXV, pp. 781-789.

The first symptom of Hy. III disease in tobacco is a clearing of the veins. This is followed later by vein banding. During clearing no anatomical or cytological abnormalities occur. The yellow colour is due to a retardation of chlorophyll formation.

When vein banding becomes apparent considerable hypertrophy is seen in the tissues near the veins and hypoplasia is apparent in the interveinal areas. Intracellular inclusions are abundant in all tissues except the xylem.

Cleared tissue contains 6-11 times as much virus per unit volume as does the banded tissue. The latter also contains less than do the yellower parts of banded leaves.

LIX. M. A. WATSON. "*Further Studies on the Relationship Between Hyoscyamus Virus 3 and the Aphis* Myzus persicae, *with Special Reference to the Effects of Fasting.*" Proceedings of the Royal Society of London, B, 1938, Vol. CXXV, pp. 144-170.

The efficiency of *Myzus persicae* in transmitting Hy. 3 virus increases with increasing time of fasting before feeding on the infected plants. Their efficiency decreases with increasing feeding time on the infected plants up to one hour, at which time a constant low level is reached. Infectivity is lost by the aphides when fasting after infection feeding, but the loss is less rapid if the feeding time on the infected plants was very short. The rate of loss of infectivity appears to be more rapid than the rate at which the virus is inactivated *in vitro* in expressed plant sap. Individual aphides vary in their efficiency as vectors, but the relative efficiency of individuals can be altered if the preliminary fasting treatments are varied. The most probable explanation of these results is that the virus is inactivated by some substance secreted by the aphides when feeding.

LX. F. M. L. SHEFFIELD. "*Micrurgical Studies on Virus-Infected Plants.*" Proceedings of the Royal Society of London, B, 1939, Vol. CXXVI, pp. 529-538.

Cells of virus-infected plants were examined by micro-manipulative methods.

The pH of the cell contents was found to be the same in diseased and in healthy plants.

The non-crystalline intracellular inclusions of aucuba mosaic disease of tomato disintegrate immediately on slight mechanical pressure or on pricking. They are almost unaffected by acids from pH 7 to 2.2. They break down if the osmotic pressure is reduced below 0.07 M, but can be isolated into solutions of O.1 M. These inclusions contain virus, but virus may also be dispersed through the cell.

The striate material of tobacco and enation mosaics cannot be isolated, as immediately it is touched with a micro-needle it breaks down into needle-like fibres.

APICULTURAL PROBLEMS

(Section for Bee Investigations)

LXI. H. L. A. TARR. "*Studies on American Foul Brood of Bees.*" *II. The Germination of the Endospores of* Bacillus larvae *in Media containing Embryonic Tissues,*" with an Appendix by W. G. COCHRAN. Annals of Applied Biology, 1938, Vol. XXV, pp. 633-643.

The difficulty of producing vegetative growth from the spores of *Bacillus larvae*, the organism responsible for American foul brood of bees, even on rich media such as a complex egg yolk carrot extract suggested the possibility of using media containing the tissues of the developing chick embryo. Experiments comparing four different media showed that chick embryo "brei" and the chorioallantoic membrane of the developing chick are by far the most favourable media yet found for the growth of this organism. Added available nitrogen in the form of beef digest broth to the embryo brei tended to inhibit germination. Concentrations of reducing sugars up to 12.5 per cent. caused no apparent reduction in the germination of *B. larvae* spores on the chick embryo media. This is of interest because of previous suggestions that the reducing sugar content of bee larvae at various stages in their development might be connected with the age-incidence of American foul brood.

LXII. H. L. A. TARR. "*Studies on American Foul Brood of Bees. III. The Resistance of Individual Larvae to Inoculation with the Endospores of* Bacillus larvae." Annals of Applied Biology, 1938, Vol. XXV, pp. 807-814.

Experiments are described in which attempts were made to produce American foul brood by the direct inoculation of eggs, or of larvae from the time of hatching up to that just subsequent to sealing, by placing aqueous suspensions of the washed spores of *Bacillus larvae* in the cells. In no case did the disease develop in the colony into which the inoculated larvae were introduced. Positive results were, however, obtained by spraying a comb containing eggs and young larvae with an aqueous suspension of the spores of *B. larvae*, the disease becoming evident seven days after spraying. Since in this case the adult bees had access to the spore suspension it can be inferred that the adult bee plays an important part in the inoculation of the brood. Experiments designed to test the possibility that *B. larvae* undergoes some change during its carriage by the adult bee yielded negative results.

LXIII. H. L. A. TARR. "*Studies on European Foul Brood of Bees. IV. On the Attempted Cultivation of* Bacillus pluton, *the Susceptibility of Individual Larvae to Inoculation with this Organism and its Localisation within its Host.*" Annals of Applied Biology, 1938, Vol. XXV, pp. 815-821.

Attempts to grow *Bacillus pluton*, the causal organism of European foul brood in bees, on the minced tissues of the chick embryo, or on its chorio-allantoic membrane were unsuccessful, in contrast to *B. larvae*, which grows well on these media. Small doses of *B. pluton* which were unable to produce growth on chick embryo medium or on beef digest brood filtrate medium were instrumental in causing European foul brood in young bee larvae when placed in the cells along with the normal brood food. Stained sections cut from larvae of all ages and showing all stages of the disease showed that *B. pluton* is localised in the food mass within the peritrophic membrane. The disease is shown to be a purely intestinal infection of the bee larva. The organism responsible is a strict parasite.

TECHNICAL AND OTHER PAPERS

GENERAL

LXIV. E. J. RUSSELL. "*Science and the Indian Peasant.*" Journal of the Royal Society of Arts, 1939, Vol. LXXXVII, pp. 662-674.

LXV. E. J. RUSSELL. "*National Planning in Agriculture: its Possibilities and its Limits.*" Nineteenth Century and After, 1938, Vol. CXXIV, pp. 187-199.

LXVI. E. J. RUSSELL. "*Poland To-day.*" Journal of the Royal Society of Arts, 1938, Vol. LXXXVII, pp. 125-128.

LXVII. B. A. KEEN. "*What Happens to Rain.*" The Listener, 1939, Vol. XXI, pp. 319-320.

LXVIII. J. MEIKLEJOHN. "*The Starling—Friend or Enemy?*" Journal of the Royal Agricultural Society of England, 1938, Vol. XCIX, pp. 37-53.

This paper contains a review of the present knowledge of the status and habits of the starling, especially those which are of agricultural importance. It also contains an estimate of the density of the starling population in several parts of England, taken from comparative counts of nests, and an account of an experiment on the recovery of plants bitten off by birds.

LXIX. E. J. RUSSELL. "*The Progress of Soil Science.*" Agriculture in the Twentieth Century. (Essays on Research, Practice and Organisation, to be presented to Sir Daniel Hall, 1939.)

LXX. E. J. RUSSELL. "*Sugar Beet Manurial Experiments. Results of the Rothamsted Station's Work.*" British Sugar Beet Review, 1938, Vol. XII, pp. 109-110.

LXXI. E. J. RUSSELL. "*Soils and Fertilisers.*" The Farmer's Guide to Agricultural Research in 1937. Journal of the Royal Agricultural Society of England, 1939, Vol. C, pp. 133-159.

LXXII. E. J. RUSSELL. "*Soil Conservation and Permanent Agriculture.*" Journal of the Australian Institute of Agricultural Science, 1939, Vol. V, pp. 21-32.

LXXIII. F. YATES and W. G. COCHRAN. "*Sampling Observations on Wheat.*" Journal of the Ministry of Agriculture, 1938, Vol. XLV, pp. 85-86, 624-627, 835-838.

LXXIV. G. NAGELSCHMIDT. "*Structure and Properties of Imperfectly Crystallised Clay Minerals.*" Report of the British Association, 1938, pp. 403-404.

LXXV. G. NAGELSCHMIDT. "*Rod-shaped Clay Particles.*" Nature, 1938, Vol. CXLII, p. 114.

In support of the suggestions that some of the minerals in clays and soil colloids may occur as rod- or needle-shaped particles, it is pointed out that other layer lattice minerals can be developed as rods under special conditions of growth (e.g. pyrophyllite from Tres Cerritas, California) and that rod-shaped minerals may have a structure based on single or double chains of silicon-oxygen tetrahedra, similar to the pyroxenes and amphiboles. An example of the latter type seems to be the series of clay minerals known as polygorskites, which include the minerals sapiolite and attapulgite.

LXXVI. R. K. SCHOFIELD. "*Physical Chemistry of Clay.*" Nature, 1939, Vol. CXLII, pp. 526-527.

LXXVII. R. K. SCHOFIELD. "*The Electrical Charges on Clay Particles.*" Soils and Fertilisers, 1939, Vol. II, pp. 1-5.

LXXVIII. R. K. SCHOFIELD. "*Physical Chemistry of Clay.*" The British Clay Worker, 1938, Vol. XLVII, pp. 208-210.

The above three papers can be summarised as follows.

Some of the charges on clay particles, due to isomorphous substitutions within the crystal lattice, are *permanent* in the sense that they are not influenced by the hydrogen ion concentration of the medium in which the clay is suspended. There are also "spots" on the particles which are charged or uncharged according to the reaction of the medium. They are of two kinds: acidic spots where negative charges can develop through the dissociation of hydrogen ions, and basic spots where positive charges can develop through the combination of hydrogen ions. The process in the case of the acidity spots is probably

$$\gt\!\mathrm{Si{-}OH} \rightleftarrows \gt\!\mathrm{Si{-}\overset{-}{O}} + \overset{+}{\mathrm{H}}$$

the silicon atoms being those situated at the edges of the silicon oxygen layer. The chemical nature of the basic spots is uncertain. They are not found in the clay minerals so far indentified but are frequent in the common clays. The equilibrium is possibly

$$-\overset{+}{\mathrm{Al}}\mathrm{{-}OH} \rightleftarrows -\mathrm{Al{=}O} + \overset{+}{\mathrm{H}}$$

and may be due to an over-crowding in the octohedral layer.

A study of the variation of the electric charge with pH enables the amounts of permanent charge and of the acidic and basic groups to be determined. In certain clays the number of basic groups exceeds the negative charges. These exhibit well-defined iso-electric points.

LXXIX. E. M. CROWTHER. "*The Determination of Silicon, Iron and Aluminium in Soils.*" Transactions of the Second Commission and Alkali Sub-Commission of the International Society of Soil Science, 1938, Vol. B, pp. 97-100.

LXXX. E. M. CROWTHER. "*The Maintenance of Soil Fertility.*" Report of the British Association, 1938, p. 519.

LXXXI. E. M. CROWTHER (with R. STEWART). "*The Separation and Analyses of Soil Clay Fractions.*" Agricultural Progress, 1938, Vol. XVI, pp. 55-60.

LXXXII. I. W. SELMAN. "*On the Use of Common Salt as a Fertiliser.*" Journal of the Ministry of Agriculture, 1938, Vol. XLV, pp. 237-246.

LXXXIII. H. V. GARNER. "*Sugar Beet Manurial Experiments.*" British Sugar Beet Review, 1939, Vol. XIII, pp. 41-43.

BIOLOGICAL

LXXXIV. H. F. BARNES. "*Recent Advances—Entomology.*" Science Progress, 1938, Vol. XXXII, pp. 542-47.

LXXXV. H. F. BARNES. "*Recent Advances—Entomology.*" Science Progress, 1938, Vol. XXXII, pp. 754-8.

LXXXVI. H. F. BARNES. "*Recent Advances—Entomology.*" Science Progress, 1938, Vol. XXXIII, pp. 117-23.

LXXXVII. D. MORLAND. "*Recent Investigations into Beekeeping at Rothamsted.*" Journal of the Royal Society of Arts, 1938, Vol. LXXXVI, pp. 394-404.

LXXXVIII. B. LOVIBOND. "*A Burying Beetle Peculiar to Sea Marsh Turf,* (Bledius tricornis *Herbst*)." Journal of the Board of Greenkeeping Research, 1938, Vol. V, pp. 217-218.

LXXXIX. K. GRANT. "*A Migration of Cabbage White Butterflies in Hertfordshire in May, 1937.*" The Entomologist, 1938, Vol. LXXI, pp. 103-108.

XC. MARY D. GLYNNE. "*Eyespot Lodging of Wheat Caused by* Cercosporella herpotrichoides *Fron.*" Agricultural Progress, 1939, Vol. XVI, pp. 1-5.

XCI. F. C. BAWDEN and N. W. PIRIE. "*A Plant Virus Preparation in a Fully Crystalline State.*" Nature, 1938, Vol. CXLI, pp. 513-514.

XCII. F. C. BAWDEN and N. W. PIRIE. "*Plant Viruses* I: *Serological, Chemical and Physico-Chemical Properties.*" Tabulae Biologicae, 1938, Vol. XVI, p. 355.

XCIII. F. C. BAWDEN. "*Crystalline and Liquid Crystalline Viruses.*" Proceedings of the Royal Society of London, B, 1938, Vol. CXXV, pp. 297-299.

XCIV. F. C. BAWDEN. "*Some Recent Work on Plant Viruses.*" Empire Journal of Experimental Agriculture, 1939, Vol. VII, pp. 1-10.

XCV. S. D. GARRETT. "*Take-all or Whiteheads Disease of Wheat and Barley and its Control.*" Journal of the Royal Agricultural Society of England, 1937, Vol. XCVIII, pp. 1-11.

XCVI. J. HENDERSON SMITH. "*Some Recent Developments in Virus Research.*" Annals of Applied Biology, 1938, Vol. XXV, pp. 227-243.

XCVII. HUGH NICOL. "*Significance of Pollen in Brood Cappings.*" The Bee World, 1939, Vol. XX, pp. 9-10.

WOBURN EXPERIMENTAL STATION REPORT FOR 1937-38.

BY DR. H. H. MANN

Season

The season of 1937-38 was a rather remarkable one. Among the many memorable features were the very wet winter, followed by a serious drought from February to April, the exceptional mildness of the early spring, the severe gales which prevailed at times, particularly at the beginning and end of June, and the series of thunderstorms during the early part of August. The most important feature from the farming point of view was the long spring drought (following on the wet winter) which led to almost record crops of those plants which were sown either before the drought appeared or whose germination was secured in spite of its prevalence, but which also resulted in very light crops of hay and in great difficulty in establishing the later spring crops like kale. The meteorological records from October 1937 to the end of 1938 were as follows :—

METEOROLOGICAL RECORDS FOR 1937-38

Month	*Rainfall*		Bright Sun-shine	*Temperature* (*Mean*)			
	Total Fall	No. of Rainy Days		Maxi-mum	Mini-mum	1 ft. in Ground	Grass Mini-mum
1937	Ins.		Hours	°F.	°F.	°F.	°F.
Oct. ..	2.75	12	73.7	57.5	42.1	51.3	37.5
Nov. ..	1.84	11	59.4	46.6	34.0	43.0	30.7
Dec. ..	2.44	23	28.7	41.1	31.8	38.6	29.1
1938							
Jan. ..	2.49	21	48.4	46.8	36.9	40.7	33.7
Feb. ..	0.63	12	65.4	45.6	35.2	39.9	32.1
Mar. ..	0.32	5	189.8	58.1	39.2	46.5	34.0
April ..	0.12	5	157.5	54.2	32.4	49.3	26.8
May ..	1.77	16	178.4	59.5	41.5	54.3	36.8
June ..	1.19	10	211.3	67.1	49.8	61.8	46.7
July ..	1.51	13	164.4	68.5	51.6	63.4	48.5
Aug. ..	2.83	14	167.7	69.5	53.1	64.8	50.9
Sept. ..	1.29	14	124.3	64.6	48.6	58.5	44.6
Oct. ..	2.88	17	128.4	56.8	42.1	50.1	37.7
Nov. ..	2.34	16	88.4	53.8	42.5	47.4	38.6
Dec. ..	3.47	21	47.8	43.3	33.5	39.2	31.1
Total or mean for 1938 ..	20.84	164	1571.8	57.3	42.2	51.3	38.5

CONTINUOUS WHEAT AND BARLEY EXPERIMENTS

The present interest of these experiments, which have been carried on ever since 1877, continues to reside in the study of the effect of fallowing, without further manure, on the crops of wheat or barley. Two two-year fallows have been taken in recent years: in 1926 and 1927, and again in 1934 and 1935. The crop in 1938 was thus the third after a two-year fallow, and thus assists in determining how far the previous manuring for fifty years has affected the power of recovery of the soil through fallowing.

(*a*) *Continuous Wheat.*—" Red Standard " wheat was sown on November 8th, and a good plant was obtained and developed normally. On the whole the weediness did not appear to have increased much since the fallow, except on the very acid plots (2a, 5a, and 8a and b) but on these the two twitches (*Holcus mollis* and *Agrostis stolonifera*) which prevail in this field proved absolutely uncontrollable, and the condition has reverted almost to the condition before the last two year fallow. There was little of the weed *Vicia hirsuta* or wild vetchling, which has been such a nuisance on certain plots, but this is probably a seasonal matter.

The yield on the various plots is shown in the following table.

TABLE I.

Continuous Growing of Wheat, 1938—*after* 2 *years'* (1934—1935) *fallowing and previous fallowing*, 1927 *and* 1928.

Stackyard Field *Produce per acre*

Plot	Manures Applied Annually. (Before the Fallow.) For amounts see Report 1927-1928 No manures since 1926	Dressed corn per acre bushels	Total corn per acre lb.	Weight per bushel lb.	Straw, chaff, etc., per acre lb.
1	Unmanured	12.5	772	60.9	1177
2a	Sulphate of ammonia	0.9	57	—	98
2aa	As 2a, with lime, Jan., 1905, repeated 1909, 1910, 1911	4.7	286	60.0	399
2b	As 2a, with lime, December, 1897	13.3	817	61.0	980
2bb	As 2b, with lime, repeated Jan., 1905	14.2	871	60.5	10-7
3a	Nitrate of soda	10.6	656	61.0	898
3b	Nitrate of soda	10.0	620	61.0	771
4	Mineral manures (superphosphates and sulphate of potash)	14.1	868	61.1	1321
5a	Mineral manures and sulphate of ammonia ..	14.4	386	61.2	1041
5b	As 5a, with lime, Jan., 1905	13.5	834	62.5	992
6	Mineral manures and nitrate of soda	13.4	829	61.2	1148
7	Unmanured	13.4	820	60.7	1163
8a	Mineral manures and, in alternate years, sulphate of ammonia	2.5	156	—	230
8aa	As 8a, with lime, Jan., 1905, repeated Jan., 1918	8.6	522	60.5	674
8b	Mineral manures and sulphate of ammonia (omitted in alternate years)	2.2	136	—	181
8bb	As 8b, with lime, Jan.,1905, repeated Jan., 1918	12.1	744	61.0	921
9a	Mineral manures and, in alternate years, nitrate of soda	13.2	815	61.2	1197
9b	Mineral manures and nitrate of soda (omitted in alternate years)	16.7	1049	62.4	1451
10a	Superphosphate and nitrate of soda	13.0	802	61.0	932
10b	Rape dust	13.8	853	61.2	1008
11a	Sulphate of potash and nitrate of soda ..	15.7	973	61.2	1271
11b	Farmyard manure	16.5	1014	61.2	1483

The chief interest of these figures lies in the relation of previous manuring to the capacity for recovery of fertility by means of fallowing. This is shown in the following figures for certain selected plots.

Yield of dressed corn per acre

Plot	1877-86 (with manures)	1917-26 (with manures)	1929 After two years' fallow	1936	1937	1938
				After two years' fallow		
			(no manures since 1926)			
	bushels	bushels	bushels	bushels	bushels	bushels
1	16.8	3.6	11.1	10.7	17.9	12.5
2a	25.4	0.3	0.3	no crop	2.3	0.9
2b	——	4.3	1.1	13.7	12.9	13.3
3b	24.1	7.1	9.5	13.4	11.5	10.0
4	17.7	4.4	17.8	15.8	18.6	14.1
5a	31.5	5.1	10.9	15.3	8.5	14.4
5b	——	7.4	13.3	14.8	13.5	13.5
6	32.4	8.6	12.8	11.4	12.0	13.4
7	17.4	4.0	8.5	13.0	16.0	13.4
11b	26.7	9.5	21.3	14.3	11.6	16.5

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The recovery of the yield after the fallows is very noteworthy; so is the maintenance of the recovered yield even in the third year after the fallow in the present case, in spite of the absence of any manuring since **1926**. This applies to all plots, but the outstanding character of the plot to which farmyard manure had been applied for the first fifty years of the experiment seems now almost to have disappeared. There has been little or no recovery of the plots made acid by treatment with sulphate of ammonia either by fallowing or by absence of any further addition of this salt.

(*b*) *Continuous Barley.* " Plumage Archer " barley was sown on February **24**th, and a good plant was obtained which grew normally, considering the exceeding poverty of these plots. The yield on the various plots is shown in the following table.

TABLE II

Continuous Growing of Barley, 1938—*after* 2 *years'* (1934-1935) *fallowing and previous fallowing,* 1926 *and* 1928

Stackyard Field *Produce per acre*

Plot	Manures Applied Annually (Before the Fallow.) For amounts see Report 1927-1928 No manures since 1926.	Dressed corn per acre bushels	Total corn per acre lb.	Weight per bushel lb.	Straw, chaff, etc., per acre lb.
1	Unmanured	17.3	862	49.7	803
2a	Sulphate of ammonia	0.4	21	—	?
2aa	As 2a, with lime, Mar., 1905, repeated 1909, 1910, 1912 and 1923	15.8	787	49.5	800
2b	As 2a, with lime, Dec., 1897, repeated 1912	12.1	585	48.0	797
2bb	As 2a, with lime, Dec., 1897, repeated Mar., 1905	14.9	728	48.5	636
3a	Nitrate of soda	20.0	1025	51.0	898
3aa	As 3a, with lime, Jan., 1921	16.7	814	48.5	782
3b	Nitrate of soda	16.9	851	50.0	678
3bb	As 3b, with lime, Jan., 1921	10.4	510	48.5	509
4a	Mineral manures (superphosphate and sulphate of potash)	10.5	529	50.2	532
4b	As 4a, with lime, 1915	18.2	916	50.2	784
5a	Mineral manures and sulphate of ammonia	1.5	74	—	?
5aa	As 5a, with lime, Mar., 1905, repeated 1916	6.5	320	49.0	377
5b	As 5a, with lime, Dec., 1897, repeated 1912	18.9	942	49.7	851
6	Mineral manures and nitrate of soda	18.3	993	54.1	646
7	Unmanured	10.4	514	49.1	537
8a	Mineral manures and, in alternate years, sulphate of ammonia	2.8	140	—	?
8aa	As 8a, with lime, Dec., 1897, repeated 1912	17.9	919	51.0	898
8b	Mineral manures and sulphate of ammonia (omitted in alternate years)	2.9	144	—	?
8bb	As 8b, with lime, Dec., 1897, repeated 1912	21.4	1093	51.0	763
9a	Mineral manures and, in alternate years, nitrate of soda	20.5	1038	50.5	788
9b	Mineral manures and nitrate of soda (omitted in alternate years)	20.4	1042	51.1	669
10a	Superphosphate and nitrate of soda	9.5	510	53.2	508
10b	Rape dust	8.1	434	53.5	356
11a	Sulphate of potash and nitrate of sada	14.7	797	54.0	612
11b	Farmyard manure	18.4	1006	54.5	836

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Considering the circumstances, the crop of barley was astonishingly good, and the effect of the two-years' fallow has evidently lasted at least until the third year after the fallow, as the following figures show.

Yield of dressed corn per acre

Plot	1877-86 (with manures)	1917-26 (with manures)	1929	1931	1936	1938
			After two years' fallow		After two years' fallow	
			(no manures since 1926)			
	bushels	bushels	bushels	bushels	bushels	bushels
1	26.9	8.5	20.4	11.2	19.8	17.3
2a	39.4	1.5	2.7	none	none	0.4
2b	——	8.7	24.9	10.1	19.0	12.1
3b	40.4	8.7	27.2	10.3	19.2	16.9
4a	23.3	10.1	21.1	16.8	18.2	10.5
4b	——	11.5	24.8	9.4	20.2	18.2
5a	43.0	4.9	5.8	none	none	1.5
5b	——	13.4	24.2	13.4	17.4	18.9
6	46.0	16.8	30.6	11.9	22.9	18.3
7	23.0	7.3	20.2	10.0	16.3	10.4
11b	40.0	25.9	34.7	22.0	29.7	18.4

The falling off in the years succeeding the fallow has been of the same order in the two occasions quoted, though it is certainly not greater in the later case, when the soil would presumably be more exhausted than after the first fallow.

GREEN MANURING EXPERIMENTS

A new long-term experiment on the effect of tares, mustard, clover and ryegrass as green manures, either alone or in conjunction with applications of farmyard manure, straw, and varying amounts of sulphate of ammonia on the yield of kale was started in 1936. Unfortunately, as can be seen from pp. 133-134, this experiment has not yet given any definite results as the kale crop has been almost a complete failure in the last two years. The plan of the experiment involves growing the kale crop after the burial of the green manure crop grown in the same year. This is possible provided the weather in or about June is suitable for the burial of the green crops and the sowing of the kale. Neither in 1937 nor 1938 was this the case, and hence the kale crop was sown late and had to be re-sown in the middle of August, with the consequence that the crop was very small. Kale has been used in this experiment because the other green manure experiment now running, in which mustard and tares are buried, has shown that it is a very sensitive means of testing the effect of green manures on the succeeding crop.

ALTERNATE HUSBANDRY EXPERIMENT

In recent years, it has been contended that the best way of maintaining the fertility of land is to have an alternation of " ley " crops such as grass and clover, or lucerne, occupying the land for several years, and arable crops which would utilise the fertility accumulated during the time the " ley " crops were on the land. How far this is more effective than a proper use of artificial manures, and small amounts of farmyard manure on a continuous arable rotation, in maintaining the fertility of land is a doubtful question, and it seemed of importance for a direct test to be made of the two methods in a light soil such as occurs at Woburn. Such an experiment has, therefore, been established in Stackyard Field at Woburn in 1938, and the present report contains, in a separate section, the first year's results. The experiment consists of a five year rotation, three years of which may be under either a seeds ley or under lucerne. Reference for details may be made to the separate section of this report dealing with the experiment in question, pp. 135-139.

LUCERNE INOCULATION EXPERIMENT

In 1932 a series of plots was laid down to test the effect of inoculation of the seed on the yield and character of lucerne and so 1938 is the seventh year of the growth of the crop. The results have shown no increase of yield due to the inoculation, though the nitrogen content of the fodder from the inoculated plots was greater in the earlier years. The plots have continued to yield very heavy crops, though, in spite of all that could be done, weeds and grass are now tending to smother out the lucerne. The crop has, however, been maintained by very thorough harrowing of the area after the final cutting has been taken in each year, repeated several times during the succeeding winter, and, in the last four years, a dressing of farmyard manure (10 tons per acre) applied as a top dressing in January of each year. The actual yield of lucerne hay for each year since it was planted is shown in the following table.

Yield of lucerne hay per acre

Plots	1932	1933	1934	1935	1936	1937	1938	Total
	tons	tons	tons	tons	tons	tons	tons	tons
Uninoculated . .	0.70	3.28	4.07	6.55	4.37	5.02	3.42	27.41
Inoculated . .	0.68	3.12	3.96	6.48	4.29	4.98	3.11	26.62
Mean of all plots	0.69	3.20	4.01	6.52	4.33	5.00	3.27	27.02

It is anticipated that it will not be possible to maintain this area under lucerne for more than another year, owing to the increase of grasses and weeds, which have now seriously invaded the area in spite of the annual and frequent harrowing.

OTHER FIELD EXPERIMENTS

An account of the following experiments will be found in the statistical section of this report.

1. *Six Course Rotation Experiment.* This has been carried out ever since 1930, using no outside organic manures, but applying varying amounts of nitrogen (in the form of sulphate of ammonia), potash (in the form of muriate of potash), and phosphoric acid (in the form of superphosphate) for each crop. 1938 is the ninth crop of the series. The rotation used consists of barley, clover, wheat, potatoes, rye, and sugar beet.

2. *The Manuring of Sugar Beet.* This is a study of the effect of farmyard manure applied in the autumn, and of common salt, superphosphate, and muriate of potash, applied either in the previous autumn, in the early spring, or at the time of sowing, on the sugar beet crop in the light sandy soil at Woburn.

3. *The Manuring of Market Garden Crops with Concentrated Organic and other Nitrogenous Manures.* The crop used in 1938 was kale and the manures investigated were soot, dried poultry manure, rape dust, compared with sulphate of ammonia, with or without the addition of dressing of farmyard manure.

POT CULTURE EXPERIMENTS

The work in the pot culture house outlined in the last report has been continued. The experiments on clover sickness have reached the point that we have been able definitely to cure this disease by heating the soil to 135-140° F. though it reappears if clover is again continuously grown on this soil. In **1936** the still more important discovery was made that a liberal application of farmyard manure was successful in preventing clover sickness from appearing in the crop, while artificial manures had no such effect. The results have now been published in detail (see Paper IX, p. **75**, of this Report). We are now preparing further lots of soil sufficiently clover sick for further experiments on the subject.

The study of questions relating to the nutrition of barley on the extremely acid soils produced by the continued use ot sulphate of ammonia has been continued, and an account of them and the results obtained are now almost ready for the press. It is hoped that these will be published during the present year.

Work has also continued on the effect of manuring with various forms of organic material chiefly with those that might be used as green manures, in comparison with farmyard manure and with sulphate of ammonia. The results are now being prepared for publication.

FARM REPORT

From the point of view of yield, the season of **1937-38** was a good one, at least in certain cases. All the autumn-sown crops did well, and also those that were sown early enough in the spring to be established before the drought became serious. Record yields were, in fact, obtained with wheat, barley and potatoes, and, even with sugar beet, the early sowing enabled a very good crop to be obtained. On the other hand, the hay crop was very light, and the late spring crops such as kale were inferior and only yielded moderately.

On Stackyard Field the area known as " Series C " was fallowed in preparation for another experiment, and the year appeared to be suitable for the purpose, the spring drought allowing a large part of the " twitch " to be eliminated. The area known as " Series D " in the same field, which was similarly cleaned in the previous year, has now been devoted to the long period experiment (see above) on alternate husbandry.

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As far as livestock are concerned, cattle, sheep and pigs did very well during the year, but the very high price of feeding stuffs did away with any possibility of large profits. A number of prizes for both sheep and pigs were obtained at the County Show in July 1938, including the first prize for a bacon pig. The farm shepherd (D. B. McCallum) obtained a prize for percentage of lambs to ewes in the season 1937-38.

The year closed with a breeding flock of 88 ewes, all being cross bred with two Hampshire rams. The number of pigs was reduced during the year owing to the very high price of feeding stuffs, but the year closed with a herd of 128 animals.

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, WOBURN, 1938

Field	Crop	Variety	Principal Cultivations and Dates	Sowing Dates	Cutting or Raising Dates	Carting Dates	Manuring per acre	Yield per acre
1. *Arable* Butt Close	Sugar Beet	Klein-wanzleben E	1937, Dec. 8-29—Plough: 1938, Apl. 13—Harrow: Apl. 14—Sow and harrow: May 12-18—Hand-hoe: May 19 to June 7—Single to 9 ins. apart: June 15-30—Resingle and clean rows.	April 14	October 17 to 30	—	2cwt. Sulphate of Ammonia	10 tons clean roots
Butt Furlong	(1) Wheat	Red Standard Yeoman II Square Head's Master	1937, Oct. 31—Plough: Nov. 4—Harrow, sow, and harrow: Nov. 24—Apply artificial manure: 1938, June 13-14—Hand-hoe.	Nov. 4, 1937	August 3	August 16 and 17	2 cwt. Sulphate of Ammonia	Yeoman II. 20.8 cwt. Sq. Head's Master 22.4 cwt.
	(2) Brussels Sprouts and Cabbages	—	1937, Oct. 29 to Nov. 20—Lift previous crop of sugar beet: 1938, Jan. 15-30—Apply farmyard manure: Feb. 1 to Mar. 25—Plough: May 25—Scuffle: May 28—Horse-hoe: May 31 to June 29—Plant out Brussels Sprouts: July 12—Sow cabbages (Christmas drum-head): July 15 and Aug. 20—Apply artificial manure.	May 31 and June 29—Transplant Brussels Sprouts July 12—Sow Cabages	At intervals to March, 1939	—	20 tons Farmyard manure 1 cwt. Sulphate of Ammonia	Sold standing
Lansome Field	(1) Lucerne	Grimm	(Planted in 1932.) 1937, Oct. 28, Nov. 22, Dec. 17; 1938, Jan. 10, Feb. 1-2—Harrow thoroughly: Feb. 1-6—Haul on and spread dung: June 21—First cutting: June 22 and 29—Harrow: Aug. 9—Second cutting: Aug. 10—Harrow: Nov. 2—Third cutting.	—	June 21 August 9 November 2	—	10 tons farmyard manure	3¼ tons hay
	(2) Barley (Old green manuring plots)	Plumage Archer	1937, Sept. 30 and Nov. 17—Cultivate with spring-tine harrow: 1938, Feb. 1—Harrow: Feb. 7-10—Plough: Mar. 11—Harrow, drill, and harrow: Apl. 30—Apply artificial manure: May 4—Roll.	March 11	August 16	August 19	1 cwt. Sulphate of Ammonia	15 cwt. grain

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, WOBURN, 1938 (*Continued*)

Field	Crop	Variety	Principal Cultivations and Dates	Sowing Dates	Cutting or Raising Dates	Carting Dates	Manuring per acre	Yield per acre
Stackyard Field	(3) Barley (Commercial Land)	Plumage Archer	Feb. to Mar. 14—Plough: Mar. 15—Harrow, sow, and harrow: May 4—Roll.	March 15	August 15	August 18	—	24 cwt. grain
	(1) Permanent Wheat	Red Standard	1937, Sept. 30-Oct. 2—Plough: Nov. 8—Harrow, sow, and harrow: 1938, March 16—Harrow: Apl. 8 and at intervals—Hand-hoe weedy plots.	November 8, 1937	August 17	August 22	—	7.3 cwt. grain
	(2) Permanent Barley	Plumage Archer	Jan. 3-6—Plough: Feb. 24—Cultivate, then harrow, sow, and harrow: May 3-20—Hand-hoe: May 28—Roll.	February 24	August 23	August 30	—	7.2 cwt. grain

II. *Grassland.*

The following fields were laid in for hay and cut on the dates mentioned: Roadpiece Field (4 acres)—July 15: Warren Field—July 20.

The remainder of the grassland, viz.: Great Hill Bottom, Honeypot, Broad Mead, Long Mead, Mill Dam Close, and the N.W. end of Butt Furlong, were grazed and cut over.

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, ROTHAMSTED, 1938

Field	Crop	Variety	Principal Cultivations and Dates	Manuring per acre	Sowing Date	Cutting Date	Carting Date	Yield per acre
Arable Great Knott	Spring Oats	Star	T. cultivated Sept. 15 to Oct. 18. H. ploughed Jan. 4 to Feb. 4. T. cultivated (after potatoes) Feb. 5 and 9. T. cultivated Feb. 24. T. rolled and spring tine harrowed Feb. 28. H. harrowed March 1 and 9. H. ring rolled March 12.	March 4 1 cwt. sulphate of ammonia	March 2 4 bushels per acre	July 29 to August 5	August 31	27.75 cwt.
Great Harpenden	Winter and Spring Beans	—	Ploughed in winter beans Oct. 25. H. harrowed winter beans Feb. 23. Ploughed in spring beans Feb. 24 and 25. H. harrowed spring beans March 21. H. hoed April 6 to May 2. Hand hoed May 26 to June 3. Spring beans failed.	Oct. 25 10 tons F.Y.M. for winter beans. Feb. 23 10 tons F.Y.M. for spring beans	Oct. 26 (winter beans) Feb. 24 & 25 (spring beans)	August 3	August 31	12.5 cwt.
Little Hoos	Barley	Abed Kenia	Finished folding kale March 5. H. and T. ploughed Feb. 19 to March 19. T. disc harrowed May 10. H. ring rolled May 18. T. disced and rolled, and spring tine harrowed May 20. H. harrowed and ring rolled May 21 and 23. Crop failed and commenced folding sheep Aug. 4.	May 20 2 cwt. sulphate of ammonia 3 cwt. superphosphate	May 23	—	—	—
Long Hoos I, II and III	Wheat	Victor	H. and T. ploughed Sept. 17 to 27. T. spring tine harrowed and rolled Oct. 29. H. harrowed Nov. 8 to 12, and Mar. 15. H. ring rolled Mar. 18. Hand hoed weeds Mar. 16 to 25.	March 14 1½ cwt. sulphate of ammonia	Nov. 8 and 10	Aug. 9 to 12	Aug. 24 and 27	40.6 cwt.

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, ROTHAMSTED, 1938 (*Continued*)

Field	Crop	Variety	Principal Cultivations and Dates	Manuring per acre	Sowing Date	Cutting Date	Carting Date	Yield per acre
Pennell's Piece	Potatoes	King Edward VII	H. ploughed Sept. 6 to 10. T. cultivated Feb. 23 and Mar. 8. T. rolled and spring tine harrowed Mar. 8. H. harrowed Mar. 9. Ridged Mar. 10. Rolled and re-ridged April 15. Hand hoed weeds June 21.	April 19 & 20 8 tons F.Y.M. April 14 3 cwt. superphosphate $1\frac{1}{2}$ cwt. sulphate of potash $1\frac{1}{2}$ cwt. sulphate of ammonia	April 21	—	Oct. 12 Potatoes lifted	—
Harwood's Piece	Barley	Plumage Archer	T. ploughed Feb. 7 to 9. T. cultivated Feb. 26. T. rolled and spring tine harrowed Mar. 3. H. harrowed Mar. 3. H. ring rolled April 11.	March 3 3 cwt. superphosphate April 11 1 cwt. sulphate of ammonia	Mar. 3 and 4	Aug. 4 and 5	Aug. 18 to 20	31.56 cwt.
Bones Close	Fallow	—	T. cultivated Oct. 6. T. ploughed Mar. 1. T. rolled and spring tine harrowed Mar. 17 and repeated twice June 3. T. thistlebar July 6 and Sept. 1.	—	—	—	—	—
Fosters	Kale	Thousand Head	T. shallow ploughed Sept. 13. T. cultivated Oct. 4. H. ploughed Mar. 7 to April 7. H. ring rolled May 10 to 12. T. disc harrowed May 12. T. rolled and spring tine harrowed May 18 and 19. H. harrowed and rolled May 31 and June 1 (most of first sowing failed). T. thistlebar most of field July 5. H. harrowed July 5. H. hoed June 30, July 8 and 9, Aug. 15 to 27.	June 1 3 cwt. sulphate of ammonia July 19 3 cwt. sulphate of ammonia	June 1 (1st sowing) July 7 (2nd sowing)	—	Kale folded Feb. 11 to Mar. 15	Estimated yield 20 tons

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, ROTHAMSTED, 1938 (*Continued*)

Field	Crop	Variety	Principal Cultivations and Dates	Manuring per acre	Sowing Date	Cutting Date	Carting Date	Yield per acre
Pastures	Kale and Annual Experiments	Marrow stemmed	T. cultivated stubble twice Sept. 16 to 30. H. and T. ploughed Feb. 17 to 21. T. cultivated both ways Mar. 8 and 9. T. rolled and spring tine harrowed Mar. 12 and 17, and twice on May 5. H. harrowed and ring rolled May 12 and 20. H. hoed June 16 to July 15. Hand hoed thistles June 23.	April 4 3 cwt. superphosphate May 19 4 cwt. sulphate of ammonia July 19 3 cwt. sulphate of ammonia (all to kale)	May 19	—	Kale folded Jan. 12 to 29	Estimated yield 30 tons
Grassland :								
Great Field I	Grazed	Old Pasture	T. chain harrowed Mar. 30. Topped June 17 to July 25.	—	—	—	—	—
II	do.	do.						
III	do.	do.						
Great Knott I	do.	See Report 1931	T. chain harrowed April 1. Topped July 7.	—	See Report 1931	—	—	—
II	do.	do.	H. chain harrowed Jan. 10.	—	do.	—	—	—
Little Knott I and II	do.	do.	Topped Aug. 31.	—	do.	—	—	—
West Barnfield I and II	do.	do.	Topped July 8.	—	do.	—	—	—
Stackyard	do.	do.	H. chain harrowed Jan. 10 and 14. T. chain harrowed Mar. 31. Topped Aug. 8.	—	do.	—	—	—
New Zealand	do.	do.	T. chain harrowed Mar. 31.	—	do.	—	—	—
Sawyers I	do.	do.	Topped Sept. 19 and 21	—	do.	—	—	—
II	do.	do.	Topped July 8.	—	do.	—	—	—
III	do.	do.	Topped Sept. 22.	—	do.	—	—	—
Hill Harpenden	do.	Old Pasture	T. chain harrowed Mar. 23. Topped July 22.	—	—	—	—	—
Delharding	do.	do.	T. chain harrowed Mar. 19. Topped July 11.	—	—	—	—	—
Appletree	do.	do.	T. chain harrowed Mar. 22.	—	—	—	—	—
Foster's Corner	do.	See Report 1931		—	do.	—	—	—
High Field	do. R.A.S.E. experiment	Old Pasture	T. chain harrowed twice Mar. 23-30. Cut nettles June 27.	—	—	—	—	—

DETAILED RESULTS OF THE EXPERIMENTS 1938

Notes on the Construction and Use of the Summary Tables in the remainder of this Report are given in the 1936 Report, pp. 170-173.

CHEMICAL ANALYSES OF MANURES USED IN REPLICATED EXPERIMENTS, 1938

Manures	%N	$\%P_2O_5$	$\%K_2O$
Poultry Manure	3.52	3.09	1.62
,, ,, ...	3.77	3.17	1.68
,, ,, (1)	4.10	3.57	1.90
,, ,, ...	3.69	3.52	2.12
Rape Dust	5.41	1.77	1.01
Soot	4.03, 4.83		
Town refuse (2)	1.00		
,, (3)	0.77		
,, (4)	0.62		
,, (5)	0.68		
,, (6)	1.01		
Dung (7)	0.66		
,, (8)	0.69	0.83	0.75
,, (9)	0.70	0.73	0.94
,, (10)	0.75	1.00	1.14
,, (11)	0.92	0.46	1.07
Rotted normal (12)	0.75	0.37	0.94
Rotted strawy (12)	0.74	0.39	1.06
Fresh normal (12)	0.66	0.28	0.82
Fresh strawy (12)	0.64	0.24	0.74

Sulphate of ammonia	21.1, 21.2	%N
Nitrate of soda	16.1	
Nitrochalk	16.0	
Cyanamide	20.9, 21.1	
Superphosphate	17.0 Total 15.8 Water Sol.	$\%P_2O_5$
Basic-slag, high-sol.	15.8 Total 15.0 Citric Sol.	
Sulphate of potash	49.1	$\%K_2O$
Muriate of potash	50.2, 53.2	
Muriate of potash (high grade)	63.1	

(1) Rothamsted and Woburn Experiments.
(2) Woburn Experiment.
(3) Rothamsted Experiment.
(4) Tunstall Experiment.
(5) Rochester Experiment.
(6) Chichester Experiment.
(7) Rothamsted Sugar Beet Experiment.
(8) Rothamsted Kale, Organic Manures Experiment.
(9) Rothamsted Kale, Town refuse Experiment.
(10) Woburn Kale, Organic Manures Experiment.
(11) Woburn Kale, Town refuse Experiment.
(12) Rothamsted Potato Experiment.

Three Course Rotation

Manures	% Organic Matter	% N	$\% P_2O_5$	$\% K_2O$
Chaffed straw	77.4	0.54	0.30	1.66
Adco	12.7	0.42	0.39	0.30
Superphosphate	—	—	16.8(1) 17.0(2)	—
Sulphate of ammonia ..	—	21.1 (1) (2)	—	—
Muriate of potash	—	—	—	51.4(1) 53.2(2)
Sulphate of potash ..	—	—	—	49.1
Nitrate of soda	—	16.1	—	—

(1) Applied in Autumn. (2) Applied in Spring.

Four Course Rotation

Manures	% Organic Matter	% N	% P_2O_5	% K_2O
Chaffed straw	77.4	0.54	0.30	1.66
Dung	14.7	0.52	0.40	1.32
Adco	12.7	0.42	0.39	0.30
Superphosphate	—	—	16.8 (1) (2)	—
Mineral phosphate (90% through 120 mesh)	—	—	25.9 (1) (2)	—
Muriate of potash	—	—	—	51.4 (1) (2)
Sulphate of ammonia	—	21.1	—	—

(1) Applied in Autumn. (2) Applied in Spring.

Six Course Rotation

Sulphate of ammonia	21.2 % N
Superphosphate	16.8(1), 17.0(2), % P_2O_5 (Total)
Muriate of potash	51.4(1), 53.2(2), % K_2O

(1) Applied in Autumn. (2) Applied in Spring.

Long Period Cultivation Experiment

Cyanamide	21.1 % N
Nitrochalk	16.0 % N
Superphosphate	17.0 % P_2O_5 (Total)
Muriate of potash	53.2 % K_2O

AVERAGE WHEAT YIELDS OF VARIOUS COUNTRIES

Country	Mean yield per acre, 1928-37 cwt.	Country	Mean yield per acre, 1928-37 cwt.
Great Britain	17.8	Denmark	23.4
England and Wales	17.6	Argentine	7.2
Hertfordshire	16.6	Australia	6.2
France	12.0	Canada	7.0
Germany	17.3	United States	7.1
Belgium	20.6	U.S.S.R. (Europe and Asia)	6.4*

Note.—Figures for Great Britain, England and Hertfordshire are taken from the Ministry of Agriculture's "Agricultural Statistics," Vol. 72. Other figures from "International Year Book of Agricultural Statistics," 1930-38.

* Excluding 1931.

CONVERSION TABLE

1 acre (10 sq. chains or 4,840 sq. yards)	0.405 Hectare
1 bushel (Imperial) (8 gallons)	0.364 Hectolitre
1 lb. (pound avoirdupois)	0.454 Kilogramme
1 cwt. (hundredweight, 112 lb.)	50.8 Kilogrammes
1 ton (20 cwt. or 2,240 lb.)	1016 Kilogrammes
1 metric quintal or Doppel Zentner (Dz)	100.0 Kilogrammes 220.46 lb.
1 metric ton (tonne)	1000 Kilogrammes
1 bushel per acre	0.899 Hectolitre per Hectare
1 lb. per acre	1.121 Kilogrammes per Hectare
1 cwt. per acre	1.255 dz. per Hectare
1 ton per acre	25.11 dz. per Hectare
1 dz. per Hectare	0.797 cwt. per acre
1 kg. per Hectare	0.892 lb. per acre

In America the Winchester bushel is used = 35.238 litres. 1 English bushel = 1.032 American bushels. In America 1 cwt. = 100 lb.

The yields of grain in the replicated experiments are given in cwt. per acre. One bushel of wheat weighs 60 lb., of barley weighs 52 lb., of oats weighs 42 lb. approximately.

METEOROLOGICAL RECORDS, 1938

	Rain.		Drainage through soil.				Temperature (Mean).			
	Total fall 1/1000th Acre Gauge.	No. of Rainy Days (0.01 inch or more) 1/1000th Acre Gauge.	20 ins. deep.	40 ins. deep.	60 ins. deep.	Bright Sun-shine.	Max.	Min.	1 ft. in ground	Grass Min.
1938—	Inches.	No.	Inches.	Inches.	Inches.	Hours.	°F.	°F.	°F.	°F.
Jan. ..	3.372	21	2.679	2.864	2.713	47.1	45.7	35.9	39.7	31.7
Feb. ..	0.592	11	0.044	0.165	0.145	67.0	44.5	34.4	38.6	30.6
Mar. ..	0.318	5	0.000	0.000	0.000	176.6	57.4	37.8	43.7	30.6
April ..	0.121	5	0.000	0.000	0.000	157.1	52.5	35.6	45.4	27.4
May ..	1.840	11	0.000	0.007	0.003	161.4	58.4	41.9	50.3	37.9
June ..	0.804	7	0.000	0.000	0.000	203.1	66.7	50.1	57.9	45.3
July ..	1.218	13	0.000	0.000	0.000	143.4	67.5	51.7	59.5	47.6
Aug. ..	2.401	11	0.295	0.269	0.231	151.1	68.9	53.1	61.5	49.2
Sept. ..	1.760	15	0.471	0.423	0.397	120.0	64.1	49.4	56.9	44.9
Oct. ..	3.273	16	1.749	1.741	1.640	117.7	55.9	42.7	50.0	37.5
Nov. ..	3.542	17	2.840	2.715	2.577	68.9	52.9	41.5	47.4	37.2
Dec. ..	3.741	20	3.189	3.451	3.270	45.4	42.3	32.7	39.0	30.4
Total or Mean	*22.982*	*152*	*11.267*	*11.635*	*10.976*	*1458.8*	*56.4*	*42.2*	*49.2*	*37.5*

RAIN AND DRAINAGE

MONTHLY MEAN FOR 68 HARVEST YEARS 1870-1—1937-8

	Rain-fall.	Drainage.			Drainage % of Rainfall.			Evaporation.		
		20-in. Gauge.	40-in. Gauge.	60-in. Gauge.	20-in. Gauge.	40-in. Gauge.	60-in. Gauge.	20-in. Gauge.	40-in. Gauge.	60-in. Gauge.
	Inches	Inches	Inches	Inches	%	%	%	Inches	Inches	Inches
Sept. ..	2.432	0.831	0.811	0.748	34.2	33.3	30.8	1.601	1.621	1.684
Oct. ..	3.059	1.719	1.698	1.574	56.2	55.5	51.5	1.340	1.361	1.485
Nov. ..	2.873	2.202	2.260	2.134	76.6	78.7	74.3	0.671	0.613	0.739
Dec. ..	2.818	2.400	2.501	2.391	85.2	88.8	84.8	0.418	0.317	0.427
Jan. ..	2.452	2.018	2.209	2.110	82.3	90.1	86.1	0.434	0.243	0.342
Feb. ..	2.013	1.486	1.604	1.532	73.8	79.7	76.1	0.527	0.409	0.481
Mar. ..	1.959	1.057	1.183	1.120	54.0	60.4	57.2	0.902	0.776	0.839
April ..	2.043	0.674	0.753	0.716	33.0	36.9	35.0	1.369	1.290	1.327
May ..	2.073	0.501	0.568	0.535	24.2	27.4	25.8	1.572	1.505	1.538
June ..	2.214	0.536	0.554	0.531	24.2	25.0	24.0	1.678	1.660	1.683
July ..	2.664	0.690	0.720	0.672	25.9	27.0	25.2	1.974	1.944	1.992
Aug. ..	2.551	0.670	0.684	0.642	26.3	26.8	25.2	1.881	1.867	1.909
Year	*29.151*	*14.784*	*15.545*	*14.705*	*50.7*	*53.3*	*50.4*	*14.367*	*13.606*	*14.446*

CROPS GROWN IN ROTATION, AGDELL FIELD

PRODUCE PER ACRE

Year	Crop		O Unmanured since 1848		M Mineral Manure‡ No Nitrogen		C Complete Mineral and Nitrogenous Manure	
			5 Fallow	6 Clover or Beans	3 Fallow	4 Clover or Beans	1 Fallow	2 Clover or Beans
	Average of first twenty-two Courses, 1848-1935							
	Roots (Swedes)	cwt.*	31.4	15.5	169.6	201.9	340.4	298.9
	Barley—							
	Dressed grain	bush.	20.8	19.0	22.1	26.0	29.1	33.6
	Total straw	cwt.†	13.0	12.8	13.3	15.4	18.0	21.3
	Beans—							
	Dressed grain	bush.‡‡	—	12.6	—	18.9	—	21.2
	Total straw	cwt.‡‡	—	9.4	—	14.9	—	15.4
	Clover hay	cwt.§	—	25.6	—	52.1	—	52.0
	Wheat—							
	Dressed grain	bush.	22.7	21.3	26.5	28.8	26.7	28.3
	Total straw	cwt.†	22.8	21.2	28.5	29.7	29.4	29.0
	Present Course (23rd), 1936-8							
1936	Roots (Turnips)	cwt.	24.4	9.4	53.8	51.0	112.6	65.3
1937	Barley—							
	Dressed grain	bush.	0.6	0.4	2.7	0.5	0.9	1.5
	Total straw	cwt.†	3.4	2.1	2.5	4.7	2.7	3.4
1938	Clover hay	cwt.	—	8.3	—	29.1	—	26.4

* Plots 1, 3 and 5 based upon 20 courses. Plots 2, 4 and 6 based upon 19 courses.

† Includes straw, cavings and chaff.

‡ Mineral manure: 528 lb. 16% Superphosphate; 500 lb. Sulphate of Potash; 100 lb. Sulphate of Soda; 200 lb. Sulphate of Magnesia, all per acre. Nitrogenous Manure; 206 lb. Sulphate of Ammonia and 2,000 lb. Rape Dust per acre. Manures applied once every four years, prior to sowing of Swedes.

‡‡ Based on 9 courses.

§ Based on 13 courses.

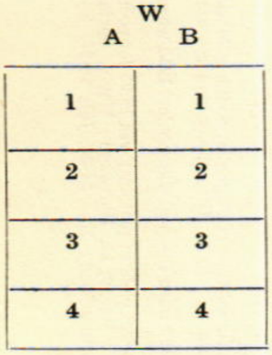
CULTIVATIONS, ETC.—Cropped sections: Seed undersown in barley, May 10, 1937. Variety: Montgomery Red. Digging out docks: May 4. Hand hoed: June 3. Cut: July 2. Fallow sections: Ploughed: Oct. 19. Cultivated: March 10. Spring-tine harrowed: May 5. Rolled May 5. Thistles cut: June 22.

WHEAT AFTER FALLOW—HOOS FIELD

Without Manure 1851, and since.

SCHEME FOR COMPARING A THREE-YEAR FALLOW WITH A ONE-YEAR FALLOW

Each of the two strips on Hoos Wheat after Fallow is divided into four parts. In the year when a strip is in crop, one quarter continues to be fallowed, so that this quarter has a three-year fallow. Different quarters are selected for fallow in successive years in the rotation given in the following table :



Cropping of strips A and B

C=Crop. F=Fallow.

Year	A1	A2	A3	A4	B1	B2	B3	B4
1932	F	C	C	C	F	F	F	F
1933	F	F	F	F	C	C	F	C
1934	C	F	C	C	F	F	F	F
1935	F	F	F	F	C	C	C	F
1936	C	C	F	C	F	F	F	F
1937	F	F	F	F	F	C	C	C
1938	C	C	C	F	F	F	F	F
1939	F	F	F	F	C	F	C	C
1940	F	C	C	C	F	F	F	F

A comparison of the effect of a three-year fallow with the effect of a one-year fallow will be possible in every year.

Half the experiment continues to be wheat after one year fallow, and continuity with previous results will thus be maintained.

Cultivations, etc.—Cropped sections : Ploughed : Sept. 23-27. Cultivated : Oct. 16. Harrowed : Nov. 6, March 17. Spring-tine harrowed : Oct. 20. Rolled : Oct. 20, March 19. Seed sown : Nov. 6. Variety : Red Standard. Harvested : Aug. 11. Fallow section : Ploughed : Sept. 23-27, June 23. Cultivated : Oct. 16, March 5. Spring-tine harrowed : May 7, June 3. Rolled : May 7, June 3. Thistles cut : June 21, Aug. 15.

PRODUCE PER ACRE, 1938

	A1	A2	A3	*Mean*	*Average* 82 *years*, *1856-1937*
Dressed Grain—bushels	33.0	29.5	30.1	*30.9*	*14.2*
Total Grain—cwt.	19.2	17.0	17.7	*18.0*	*8.1*
Weight per bushel—lb.	63.2	63.1	63.7	*63.3*	*58.9*
Total Straw—cwt.	21.2	19.4	18.9	*19.8*	*12.7*

MANGOLDS—BARNFIELD, 1938

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

PRODUCE PER ACRE

	Strip	Strip Manures (Amounts stated are per acre)	1938 Cross Dressings O None	N Nitrate of Soda (550 lb.)	A Sulphate of Ammonia (412 lb.)	AC Sulphate of Ammonia (412 lb.) & Rape Cake (2,000 lb.)	C Rape Cake (2,000 lb.)	56 Year Average, 1876-1937.† Cross Dressings O None	N Nitrate of Soda (550 lb.)	A Sulphate of Ammonia (412 lb.)	AC Sulphate of Ammonia (412 lb.) & Rape Cake (2,000 lb.)	C Rape Cake (2,000 lb.)
			Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
Roots	1	Dung (14 tons)	16.31	26.61	23.05	26.51	23.40	17.41	26.42	21.90	23.64	23.53
	2	Dung, Superphosphate (3½ cwt.), Sulphate of Potash (500 lb.)	14.31	26.76	22.62	27.14	24.49	19.08	27.19	24.91	27.53	26.52
	4	Complete Minerals: Super. and Potash as 2, Sodium Chloride (200 lb.), Sulphate of Magnesia (200 lb.) ..	3.34	(a)17.85** (b)17.17	15.57	24.83	19.74	4.69	(a)17.86 (b)18.77*	14.71	26.04	21.05
	5	Superphosphate (3½ cwt.)	2.61	15.50	4.92	4.81	8.04	4.50	15.09	6.91	9.41	10.13
	6	Super. (3½ cwt.) Sulphate of Potash (500 lb.)	2.56	14.94	12.12	17.66	15.55	4.09	15.55	13.67	22.31	18.15
	7	Super. (3½ cwt.) Sulphate of Magnesia (200 lb.), and Sodium Chloride (200 lb.)	2.19	15.21	14.80	18.61	16.32	4.83	16.51	14.95	22.06	19.25
	8	Unmanured	2.06	7.35	5.00	3.50	4.99	3.35	10.00	5.50	8.54	9.07
	9	Sodium Chloride (200 lb.), Nit. Soda (550 lb.), Sulphate of Potash (500 lb.) and Sulphate of Magnesia (200 lb.) ..	14.85	—	—	—	—	—	—	—	—	—
Leaves	1	Dung (14 tons)	4.93	7.58	7.43	9.33	8.14	3.10	4.68	4.91	5.24	4.59
	2	Dung, Superphosphate (3½ cwt.), Sulphate of Potash (500 lb.)	5.02	8.66	7.81	9.34	8.01	3.21	5.20	5.43	6.18	4.82
	4	Complete Minerals: Super. and Potash as 2, Sodium Chloride (200 lb.), Sulphate of Magnesia (200 lb.) ..	1.52	(a)5.60 (b)5.65	5.29	9.07	5.74	1.07	(a)3.89 (b)4.12*	2.93	5.26	3.39
	5	Superphosphate (3½ cwt.)	1.33	5.07	3.99	4.16	4.94	1.07	3.22	2.63	3.29	2.88
	6	Super. (3½ cwt.) Sulphate of Potash (500 lb.)	1.23	5.42	4.79	7.42	5.16	0.95	3.11	2.83	5.12	2.92
	7	Super. (3½ cwt.) Sulphate of Magnesia (200 lb.) and Sodium Chloride (200 lb.)	1.23	5.18	4.85	7.93	5.66	1.11	3.40	3.09	5.22	3.39
	8	Unmanured	1.89	4.44	3.75	3.08	3.93	0.99	3.25	2.56	3.31	2.91
	9	Sodium Chloride (200 lb.), Nit. Soda (550 lb.), Sulphate of Potash (500 lb.) and Sulphate of Magnesia (200 lb.) ..	5.37	—	—	—	—	—	—	—	—	—

** From 1904 onwards plot 4N has been divided, 4(*a*) receiving Superphosphate, Sulphate of Potash, Sulphate of Magnesia, Sodium Chloride and Nitrate of Soda, amounts as above: 4(*b*) receiving Superphosphate, Calcium Chloride (190 lb.), Potassium Nitrate (570 lb.) and Calcium Nitrate (100 lb.). Nitrogenous manures are applied 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 the seed.

† Excluding 1885 when nitrogenous fertilisers were not applied, owing to poor crop, 1908 and 1927 when the crop was swedes, 1930 when the spacing of the rows was changed, 1931 when the crop was a mixture of mangolds and swedes and 1935 when it was fallow.

* 29 years only, 1904-1937, excluding 1908, 1927, 1930, 1931 and 1935. For this period the average yield of plot 4(*a*) was 18.95 for roots and 4.04 for leaves.

CULTIVATIONS, ETC.—Ploughed: Dec. 9-Feb. 4. Dung applied: Dec. 8-9, Jan. 1-3. Cultivated: Mar. 9, 11. Harrowed: May 6. Spring-tine harrowed: Mar. 15, May 4. Rolled: Mar. 15, May 4, 6, 9. Hoed: June 3-4, 17-20, July 1-6, 21-23, Aug. 19-20. Singled: July 12-22. Manures applied: Mar. 24-28, July 26-27. Seed sown: May 6. Variety: Yellow Globe. Lifted: Nov. 8-18.

HAY—THE PARK GRASS PLOTS, 1938

Plot	Manures since 1905	Yield of Hay (cwt. per acre)						Dry Matter (cwt. per acre)					
		Not limed ***			Limed ***			Not limed			Limed		
		1st Crop	2nd Crop	*Total*	1st Crop	2nd Crop	*Total*	1st Crop	2nd Crop	*Total*	1st Crop	2nd Crop	*Total*
1	Sulhhate of ammonia (206 lb.)	0.8	1.3	*2.1*	7.2	1.5	*8.7*	0.7	0.9	*1.6*	5.9	1.2	*7.1*
2	Unmanured	2.8	0.8	*3.6*	4.3	0.3	*4.6*	2.3	0.6	*2.9*	3.5	0.2	*3.7*
3	Unmanured	3.3	0.6	*3.9*	5.2	0.1	*5.3*	2.8	0.5	*3.3*	4.0	0.1	*4.1*
4-1	Superphosphate (3½ cwt.)	3.5	0.9	*4.4*	4.3	0.3	*4.6*	2.7	0.7	*3.4*	3.3	0.2	*3.5*
4-2	As 4-1 and sulphate of ammonia (412 lb.)	3.2	5.6	*8.8*	11.7	6.1	*17.8*	2.5	4.1	*6.6*	9.2	4.2	*13.4*
5-1	Unmanured	2.5	1.7	*4.2*				1.9	1.2	*3.1*			
5-2	Superphosphate (3½ cwt.) and sulphate of potash (500 lb.)	8.0	5.2	*13.2*				6.2	3.9	*10.1*			
6	As 5-2, and sulphate of soda (100 lb.) and sulphate of magnesia (100 lb.)	17.3	7.4	*24.7*				13.6	5.3	*18.9*			
7	As 6	19.8	6.1	*25.9*	15.3	1.9	*17.2*	16.1	4.5	*20.6*	12.0	1.4	*13.4*
8	As 6 without potash	7.5	2.8	*10.3*	4.7	1.1	*5.8*	6.1	2.1	*8.2*	3.9	0.8	*4.7*
9	As 6 and sulphate of ammonia (412 lb.)	10.4	13.8	*24.2*	30.3	7.0	*37.3*	8.0	9.4	*17.4*	24.2	5.0	*29.2*
10	As 8 and sulphate of ammonia (412 lb.)	7.1	8.0	*15.1*	21.6	6.3	*27.9*	5.6	6.0	*11.6*	16.9	4.3	*21.2*
11-1	As 6 and sulphate of ammonia (618 lb.)	8.8	18.7	*27.5*	35.3	9.2	*44.5*	6.8	14.2	*21.0*	29.2	6.7	*35.9*
11-2	As 11-1 and silicate of soda (3½ cwt.)	16.6	22.8	*39.4*	42.7	10.9	*53.6*	12.7	15.9	*28.6*	33.8	8.0	*41.8*
12	Unmanured	4.7	1.2	*5.9*				3.7	0.8	*4.5*			
13	Dung (14 tons) in 1905, fish guano (6 cwt.) in 1907 and every fourth year	18.8	4.4	*23.2*	14.7	2.0	*16.7*	14.9	3.3	*18.2*	11.5	1.6	*13.1*
14	As 6 and nitrate of soda (550 lb.)	43.6	6.3	*49.9*	33.6*	13.9*	*47.5*	34.2	4.9	*39.1*	26.0	10.6	*36.6*
					30.0**	1.8**	*31.8*				23.1	1.3	*24.4*
15	As 6	10.2	4.7	*14.9*	10.3	2.0	*12.3*	8.2	3.5	*11.7*	8.0	1.5	*9.5*
16	As 6 and nitrate of soda (275 lb.)	24.5	5.3	*29.8*	19.5	3.3	*22.8*	19.0	4.0	*23.0*	15.1	2.5	*17.6*
17	Nitrate of soda (275 lb.)	11.1	3.6	*14.7*	7.9	1.5	*9.4*	8.6	2.7	*11.3*	6.4	1.2	*7.6*
18	As 6 (without superphosphate) and sulphate of ammonia (412 lb.)	2.1	0.2	*2.3*	14.8†	0.7†	*15.5*	1.7	0.1	*1.8*	12.1	0.5	*12.6*
					9.7††	1.1††	*10.8*				7.9	0.8	*8.7*
19	Dung every fourth year	16.0	4.6	*20.6*	11.0§	3.5§	*14.5*	13.0	3.5	*16.5*	8.6	2.7	*11.3*
					16.5§§	3.5§§	*20.0*				12.9	2.7	*15.6*
20	As 19 and superphosphate (200 lb.), sulphate of potash (100 lb.) and nitrate of soda (168 lb.) every intervening year	23.7	4.3	*28.0*	14.8‡	1.1‡	*15.9*	19.6	3.3	*22.9*	12.0	0.8	*12.8*
					14.8§§	1.2§§	*16.0*				12.2	0.9	*13.1*

Ground lime was applied to the southern portion (limed) of the plots at the rate of 2,000 lb. to the acre in the winters of 1903-4, 1907-8, 1915-16, 1923-24, 1927-28, 1931-32, 1935-36 and at the rate of 2,500 lb. to the acre in the winter of 1920-21 except where otherwise stated.

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

*Sun. **Shade. †6,788 lb. ††3,951 lb. §3,150 lb. §§570 lb. ‡2,772 lb. of lime.

CULTIVATIONS, ETC.—Chain harrowed: Feb. 9. Rolled: April 13. Manures applied: Feb. 9-10, Mar. 17-18, April 8. Cut: **1st Crop,** June 23-24: 2nd Crop, Oct. 31-Nov. 2.

PARK GRASS PLOTS

BOTANICAL COMPOSITION PER CENT. 1938 (*1st Crop*)

Plot	Manuring	Liming	Gramineae	Leguminosae	Other orders	" Other orders " consist largely of
3	Unmanured	Limed	36.90	9.64	53.46	*Plantago lanceolata* *Poterium sanguisorba* *Leontodon hispidus*
		Unlimed	28.53	4.18	67.29	As 3 limed
7	Complete Mineral Manure	Limed	56.14	20.48	23.38	*Taraxacum vulgare*
		Unlimed	48.01	27.99	24.00	*Centaurea nigra*
8	Mineral Manure (without Potash)	Limed	54.62	6.73	38.65	*Plantago lanceolata*
		Unlimed	33.72	11.12	55.16	*Plantago lanceolata*
9	Complete Mineral Manure and double Amm. Salts	Limed	94.00	2.22	3.78	*Rumex acetosa*
		Unlimed	0.08	99.92	—	—
10	Mineral Manure (without Potash) and double Amm. Salts	Limed	94.47	—	5.53	*Rumex acetosa*
		Unlimed	100.00	—	—	—
14	Complete Mineral Manure and double Nitrate of Soda	Limed (sun)	89.25	2.25	8.50	*Anthriscus sylvestris*
		Limed (shade)	85.54	10.07	4.39	*Anthriscus sylvestris*
		Unlimed	94.15	0.84	5.01	*Anthriscus sylvestris* *Rumex acetosa*
18	Mineral Manure (without Super.) and double Sulphate Amm., 1905 and since	L.6,788 lb.	76.19	0.17	23.64	*Taraxacum vulgare*
		L.3,951 lb.	73.59	0.16	26.25	*Taraxacum vulgare*
		Unlimed	92.34	0.16	7.50	*Centaurea nigra*
19	Farmyard Dung in 1905 and every fourth year since (omitted 1917)	L.3,150 lb.	75.66	7.63	16.71	*Plantago lanceolata* *Tragapogon pratensis*
		L.570 lb.	70.90	9.56	19.54	No weed dominant
		Unlimed	68.32	13.54	18.14	*Rumex acetosa*
20	Farmyard Dung in 1905 and every fourth year since (omitted 1917) each intervening year sulphate of Potash, Super., and Nitrate of Soda	L.2,772 lb.	63.37	9.23	27.40	*Ranunculus sp.*
		L.570 lb.	82.79	6.64	10.57	No weed dominant
		Unlimed	80.33	6.20	13.47	No weed dominant

PARK GRASS PLOTS

BOTANICAL COMPOSITION PER CENT. 1938 *(1st Crop)*

	Unlimed (U); Limed (L)	Plots	3U	3L	7U	7L	8U	8L	9U	9L	10U	10L	14U	Sun 14L	Shade 14L
	Gramineae														
1	Agrostis vulgaris		5.86	0.25	6.83	0.05	2.91	0.60	1.74	2.22	9.55	2.01	—	—	0.31
3	Alopecurus pratensis		0.70	1.07	4.59	10.83	0.31	0.40	—	49.28	0.21	51.24	45.14	15.74	10.45
4	Anthoxanthum odoratum		3.07	0.33	1.54	0.05	2.00	0.48	1.04	2.18	14.04	0.80	—	—	0.06
5	Arrhenatherum avenaceum		0.07	1.15	5.10	17.20	14.74	23.67	—	24.29	3.16	6.28	37.34	57.46	17.07
6	Avena flavescens		0.21	1.73	0.84	1.47	1.49	2.88	—	—	—	—	0.09	1.39	1.24
7	Avena pubescens		4.60	20.18	0.66	1.71	2.52	12.46	—	—	—	—	—	0.41	9.28
8	Briza media		1.12	2.31	—	—	0.16	0.96	—	—	—	—	—	—	—
9	Bromus mollis		—	—	0.05	0.34	—	—	—	0.23	—	0.05	—	—	0.12
10	Cynosurus cristatus		—	0.08	—	—	—	—	—	—	—	—	—	—	—
11	Dactylis glomerata		3.42	4.45	23.02	21.75	3.42	5.61	—	11.99	—	—	6.48	2.65	2.23
12	Festuca ovina		7.88	1.73	2.34	0.64	3.30	1.44	—	0.82	0.12	28.38	0.04	4.54	39.33
13	Festuca pratensis		—	—	—	0.54	0.16	3.00	—	—	—	—	—	—	—
14	Holcus lanatus		1.53	1.73	2.62	0.24	2.32	1.76	97.14	0.58	72.92	0.84	—	—	0.25
15	Lolium perenne		—	0.08	—	—	0.08	0.32	—	—	—	—	—	—	—
16	Poa pratensis		0.07	1.48	0.37	0.39	0.31	0.72	—	2.22	—	4.87	0.49	1.39	2.35
17	Poa trivialis		—	0.33	0.05	0.93	—	0.32	—	0.19	—	—	4.57	5.67	2.85
	Leguminosae.														
1	Lathyrus pratensis		0.49	1.32	10.72	8.13	0.12	0.12	—	2.22	—	—	0.84	2.25	9.15
2	Lotus corniculatus		2.23	3.87	2.29	—	2.16	1.24	—	—	—	—	—	—	—
3	Ononis arvensis		—	—	—	—	—	—	—	—	—	—	—	—	—
4	Trifolium pratense		1.46	4.45	14.51	8.23	8.80	5.37	—	—	—	—	—	—	0.12
5	Trifolium repens		—	—	0.47	4.12	0.04	—	—	—	—	—	—	—	0.80

PARK GRASS PLOTS

BOTANICAL COMPOSITION PER CENT. 1938 (*1st Crop*)

(*Continued*)

	Unlimed (U); Limed (L)	Plots	3U	3L	7U	7L	8U	8L	9U	9L	10U	10L	14U	Sun 14L	Shade 14L
	Other Orders.														
1 2	Ranunculus acris Ranunculus bulbosus	..	—	5.27	0.75	2.79	3.69	1.56	—	—	—	—	—	—	—
4	Cerastium vulgatum	..	—	—	—	0.05	0.04	0.08	—	—	—	—	—	—	—
5	Stellaria graminea	..	—	—	—	—	—	—	—	—	—	—	—	—	—
6	Linum catharticum	..	—	—	—	—	—	—	—	—	—	—	—	—	—
7	Agrimonia eupatoria	..	—	—	—	—	—	—	—	—	—	—	—	—	—
11	Poterium sanguisorba	..	18.06	12.69	—	—	—	—	—	—	—	—	—	—	—
13	Anthriscus sylvestris	..	—	—	—	0.39	—	—	—	—	—	—	2.48	6.48	3.65
14	Conopodium denudatum	..	0.63	0.17	0.51	0.05	0.47	—	—	—	—	—	—	—	—
15	Heracleum sphondylium	..	—	0.08	2.29	4.61	—	—	—	0.16	—	—	—	—	—
16	Pimpinella saxifraga	..	0.21	0.16	—	0.05	0.31	0.28	—	—	—	—	—	—	—
17	Galium verum	..	—	—	—	—	0.31	0.04	—	—	—	—	—	—	—
18	Scabiosa arvensis	..	0.28	3.21	—	—	0.98	3.53	—	—	—	—	—	—	—
19	Achillea millefolium	..	0.90	0.33	1.73	0.20	2.00	0.72	—	—	—	—	—	—	—
20	Centaurea nigra	..	4.39	1.07	8.05	3.14	4.56	3.49	—	—	—	—	—	—	—
22	Hieraceum pilosella	..	—	—	—	—	—	—	—	—	—	—	—	—	—
24	Leontodon hispidus	..	17.29	11.70	—	—	3.97	3.20	—	—	—	—	—	—	—
26	Taraxacum vulgare	..	0.14	0.08	0.05	7.69	0.08	0.20	—	1.44	—	—	0.27	0.81	0.62
27	Tragopogon pratensis	..	0.28	—	0.19	0.64	0.08	—	—	—	—	—	—	—	—
29	Plantago lanceolata	..	24.41	16.64	2.71	0.88	33.40	17.58	0.08	—	—	—	—	—	—
30	Veronica chamaedrys	..	0.14	0.08	—	0.05	0.08	0.36	—	—	—	—	—	—	—
31	Ajuga reptans	..	—	—	—	—	—	—	—	—	—	—	—	—	—
32	Prunella vulgaris	..	—	—	—	—	—	—	—	—	—	—	—	—	—
34	Rumex acetosa	..	0.14	1.73	4.68	2.84	3.11	7.41	—	2.18	—	5.53	2.26	1.21	0.12
35	Luzula campestris	..	0.14	0.17	0.14	—	0.12	0.04	—	—	—	—	—	—	—
36	Carex praecox	..	0.28	—	—	—	—	—	—	—	—	—	—	—	—
23	Hypochoeris radicata	..	—	—	—	—	1.96	0.04	—	—	—	—	—	—	—
12	Spiraea ulmaria	..	—	0.08	2.90	—	—	0.12	—	—	—	—	—	—	—

WHEAT—BROADBALK FIELD, 1938

Plot	Manurial Treatment (amounts stated are per acre).	Dressed Grain, bushels per acre					Total Grain, cwt. per acre					74-year Average 1852-1925 (prior to fallow). Total Grain, cwt.
		I	II	III	IV	*Mean*	I	II	III.	IV	*Mean*	
2A	Farmyard Manure (14 tons)	39.1	72.2	53.1	38.2	*50.7*	23.3	43.1	30.8	23.0	*30.0*	*16.3***
2B	Farmyard Manure (14 tons)	67.6	74.0	58.8	39.1	*59.9*	40.0	44.6	34.2	23.6	*35.6*	*19.4*
3	Unmanured since 1839	18.6	39.0	21.3	19.7	*24.6*	11.0	22.5	12.4	11.7	*14.4*	*6.7*
5	Complete Mineral Manure§§	37.2	50.5	24.1	23.9	*33.9*	21.9	30.1	14.2	14.1	*20.1*	*7.8*
6	As 5, and 2 cwt. Sulphate of Ammonia	36.6	56.6	33.2	34.4	*40.2*	22.0	32.8	19.1	20.4	*23.6*	*12.5*
7	As 5, and 4 cwt. Sulphate of Ammonia	46.4	58.4	47.3	42.0	*48.5*	28.2	34.1	27.3	24.9	*28.6*	*17.6*
8	As 5, and 6 cwt. Sulphate of Ammonia	54.5	65.2	56.4	47.5	*55.9*	33.1	38.4	32.9	28.6	*33.2*	*20.1*
9	As 5, and 275 lb. Nitrate of Soda	36.2	60.1	36.2	36.8	*42.3*	21.6	35.0	21.0	22.0	*24.9*	*13.9††*
10	2 cwt. Sulphate of Ammonia	41.2	42.5	34.8	27.4	*36.5*	24.2	25.3	20.4	16.3	*21.6*	*10.9*
11	As 10, and Superphosphate (3½ cwt.)	41.4	42.2	35.0	27.5	*36.5*	24.4	25.0	20.4	16.3	*21.5*	*12.3*
12	As 11, and Sulph. Soda (366 lb.)	42.8	48.7	41.2	39.3	*43.0*	25.5	29.2	24.0	22.9	*25.4*	*15.7*
13	As 11, and Sulph. Potash (200 lb.)	41.8	58.2	38.8	42.5	*45.3*	24.8	34.8	22.6	25.3	*26.9*	*17.0*
14	As 11, and Sulph. Magnesia (280 lb.)	40.8	44.2	37.2	37.0	*39.8*	24.2	26.0	22.1	22.3	*23.7*	*15.5*
15	As 5, and 2 cwt. Sulph. Amm. applied in Autumn	43.2	57.6	44.8	49.3	*48.7*	25.6	33.9	26.2	29.2	*28.7*	*16.1*
16	As 5, and 550 lb. Nitrate of Soda	48.5	61.1	48.9	48.3	*51.7*	29.0	36.3	28.5	28.6	*30.6*	*17.8††*
17 }	Minerals alone as 5 or 412 lb. Sulphate of Ammonia	A 37.8	57.0	43.2	46.5	*46.1*	22.5	33.8	25.2	27.6	*27.3*	A *16.1*
18 }	alone in alternate years	M 19.9	47.1	17.1	23.3	*26.9*	11.8	27.6	10.2	13.8	*15.8*	M *8.1**
9	Rape Cake (1,889 lb.)	39.3	57.5	34.8	39.5	*42.8*	23.4	34.0	20.5	23.4	*25.3*	*12.6‡*
20	As 7, without Super.	36.0	43.4	—	—	*39.7*	21.3	25.6	—	—	*23.5*	*10.3§*

FALLOWING ROTATION. After the fallows of 1925-6 to 1928-9 a regular cycle of fallowing was started in the season 1930-1. This cycle and the preceding fallows are shown in the accompanying diagram (C= crop, F=fallow). The sections (I to V) are numbered in order from the upper or western end of the field. Preparatory to the first fallow the field was harvested in five separate sections (1924-5).

Season	I	II	III	IV	V	Season	I	II	III	IV	V
1925-26	F	F	F	C	C	1930-31 and 5-6	F	C	C	C	C
1926-27	F	F	F	C	C	1931-32 and 6-7	C	F	C	C	C
1927-28	C	C	F	F	F	1932-33 and 7-8	C	C	C	C	F
1928-29	C	C	F	F	F	1933-34 and 8-9	C	C	C	F	C
1929-30	C	C	C	C	C	1934-35 and 9-40	C	C	F	C	C

For notes, see next page.

WHEAT—BROADBALK FIELD, 1938

Plot	Manurial Treatment (amounts stated are per acre).	Bushel Weight in lb.					Total Straw†, cwt. per acre					74-year Average 1852-1925 (prior to fallow). Total Straw, cwt.
		I	II	III	IV	*Mean*	I	II	III	IV	*Mean*	
2A	Farmyard Manure (14 tons)	63.5	64.7	63.2	64.3	*63.9*	46.1	61.5	48.2	41.0	*49.2*	*32.1***
2B	Farmyard Manure (14 tons)	64.3	65.0	63.3	64.4	*64.2*	48.3	64.1	51.0	41.8	*51.3*	*34.2*
3	Unmanured since 1839	63.2	62.8	62.9	63.1	*63.0*	12.5	25.6	13.1	12.9	*16.0*	*9.8*
5	Complete Mineral Manure§§	63.6	64.7	63.2	63.2	*63.7*	27.2	37.3	14.8	16.1	*23.9*	*11.5*
6	As 5, and 2 cwt. Sulphate of Ammonia	64.0	63.5	62.4	63.7	*63.4*	27.7	40.8	24.2	22.6	*28.8*	*20.3*
7	As 5, and 4 cwt. Sulphate of Ammonia	64.3	63.8	62.8	63.8	*63.7*	36.5	44.6	35.0	31.8	*37.0*	*32.1*
8	As 5, and 6 cwt. Sulphate of Ammonia	64.4	64.3	63.5	64.2	*64.1*	48.2	52.2	43.4	43.1	*46.7*	*39.8*
9	As 5, and 275 lb. Nitrate of Soda	63.5	63.6	62.4	63.7	*63.3*	28.3	43.5	26.3	26.4	*31.1*	*24.6*††
10	2 cwt. Sulphate of Ammonia	63.4	63.9	62.9	61.9	*63.0*	27.2	26.2	20.7	17.9	*23.0*	*17.8*
11	As 10, and Superphosphate (3½ cwt.)	62.8	62.9	62.5	61.9	*62.5*	29.4	28.2	21.0	16.5	*23.8*	*21.4*
12	As 11, and Sulph Soda (366 lb.)	63.2	63.4	62.5	62.5	*62.9*	31.8	35.2	21.5	26.1	*28.7*	*26.8*
13	As 11, and Sulph. Potash (200 lb.)	63.5	64.3	62.8	63.9	*63.6*	34.4	47.0	29.9	31.9	*35.8*	*30.6*
14	As 11, and Sulph. Magnesia (280 lb.)	63.5	63.2	63.7	64.2	*63.6*	30.2	32.5	25.5	25.6	*28.4*	*26.8*
15	As 5, and 2 cwt. Sulph. Amm. applied in Autumn	63.4	64.2	63.5	63.9	*63.8*	36.1	45.4	34.9	39.0	*38.8*	*28.2*
16	As 5, and 550 lb. Nitrate of Soda	64.2	64.8	63.0	63.8	*64.0*	38.3	47.2	35.2	34.5	*38.8*	*35.2*††
17	Minerals alone as 5 or 2 cwt. Sulphate of Ammonia	A 64.2	64.6	63.3	64.4	*64.1*	28.7	41.6	30.3	31.6	*33.0*	A*28.1*
18	alone in alternate years	M62.8	63.8	63.4	63.4	*63.4*	14.5	32.4	12.5	16.1	*18.9*	M*12.3*
19	Rape Cake (1,889 lb.)	63.8	64.1	62.5	63.4	*63.4*	32.6	38.7	27.1	32.0	*32.6*	*22.0*‡
20	As 7, without Super.	64.0	64.0	—	—	*64.0*	28.6	31.9	—	—	*30.3*	*18.6*§

†Includes straw, cavings, and chaff. A=Ammonia series. M=Mineral series.

**Twenty-six years only, 1900-25. ††Forty-one years only, 1885-1925. ‡Thirty-three years only, 1893-1925. §Eighteen years only, 1906-1925 (no crop in 1912 and 1914).

§§Complete mineral manure; 3½ cwt. Super., 200 lb. Sulph. Potash, 100 lb. Sulph. Soda, 100 lb. Sulph Magnesia. One cwt. per acre of Sulphate of Ammonia is applied in autumn and the remainder of the dressing 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. Minerals are always applied in autumn.

Note: There have been errors in the quantities of Sulphate of Ammonia in the Reports 1927-1937; see Errata, page 211.

CULTIVATIONS, ETC.—Cropped sections: Ploughed: Sept. 6-29. Dung applied: Sept. 22. Cultivated: Oct. 14-16. Harrowed: Nov. 4-6, Mar. 15. Spring-tine harrowed: Oct. 19. Rolled: Oct. 19, Mar. 16. Manures applied: Oct. 12-14, Mar. 11, April 7. Seed sown: Nov. 4-6. Variety: Red Standard. Harvested: Aug. 5. Fallow section: Ploughed: Sept. 6-29, June 7-11. Cultivated: Oct. 14-16. Spring-tine harrowed: Oct. 19, Mar. 5 April 2, May 5, Aug. 15. Rolled: Oct. 19, May 5.

BARLEY—HOOS FIELD, 1938

Plot	Manuring (amounts stated are per acre).		Dressed Grain bushels per acre		Total Grain cwt. per acre	Bushel weight in lb.	Total Straw cwt. per acre†	
			1938	*Average 1852-1928*			1938	*Average 1852-1928*
1O	Unmanured		19.7	*13.4*	10.1	55.8	8.2	*7.8*
2O	Superphosphate (3½ cwt.)		25.0	*19.0*	12.8	55.5	9.1	*9.8*
3O	Alkali Salts (see below)		23.9	*14.3*	12.1	55.2	10.4	*8.7*
4O	Super. and Alkali Salts		28.6	*19.0*	14.6	55.8	11.9	*11.2*
5O	Super. and Potash (200 lb.) ..		18.7	*15.5*	9.6	55.2	9.5	*9.4*
1A	As 1O	and sulphate of ammonia (206 lb.). ..	27.4	*23.7*	14.2	56.0	12.0	*13.7*
2A	As 2O		34.9	*35.8*	17.0	51.8	13.3	*20.4*
3A	As 3O		32.7	*25.8*	16.4	54.7	14.9	*16.0*
4A	As 4O		34.1	*39.3*	18.4	57.3	14.5	*23.6*
5A	As 5O		37.8	*33.8*	19.7	56.6	17.6	*21.7*
1AA	As 1O	and nitrate of soda (275 lb.).	33.0	*24.3**	17.6	56.8	16.2	*15.4**
2AA	As 2O		46.4	*38.8**	23.3	55.0	17.5	*23.1**
3AA	As 3O		37.4	*24.5**	19.5	56.4	17.6	*16.6**
4AA	As 4O		44.5	*37.7**	23.0	56.8	19.6	*23.6**
1AAS	As 1AA	and silicate of soda (400 lb.).	36.9	*30.2**	19.4	57.3	19.5	*18.2**
2AAS	As 2AA		44.9	*39.7**	23.3	55.9	19.1	*23.9**
3AAS	As 3AA		38.4	*31.2**	19.7	55.9	18.0	*19.9**
4AAS	As 4AA		43.8	*39.9**	22.8	56.9	20.4	*25.4**
1C	As 1O	and rape cake (1,000 lb.).	41.4	*35.5*	21.7	57.2	17.4	*20.6*
2C	As 2O		43.6	*38.1*	22.6	56.4	17.9	*22.0*
3C	As 3O		34.8	*33.7*	17.9	56.1	16.0	*20.4*
4C	As 4O		37.6	*37.5*	19.4	56.5	16.4	*22.6*
7-1	Dung (14 tons) 1852-71 : afterwards unmanured		33.8	*22.5‡*	17.4	56.3	14.0	*13.5‡*
7-2	Farmyard Manure (14 tons) ..		75.8	*44.6*	39.4	57.2	33.8	*28.1*
6-1	Unmanured		25.9	*14.7*	13.0	55.1	10.8	*8.6*
6-2	Ashes from Laboratory furnace 1852-1933 : afterwards unmanured		23.5	*15.7*	12.2	56.0	10.3	*9.3*
1N	Nitrate of Soda (275 lb.)		32.5	*28.7§*	16.9	55.6	15.4	*17.8§*
2N	Nitrate of Soda (550 lb., 1852-7, afterwards 275 lb.)		38.8	*31.7§§*	20.3	56.9	18.1	*20.0§§*

Alkali salts consisted of 200 lb. sulphate of potash, 100 lb. sulphate of soda and 100 lb. sulphate of magnesia.

In 1912 and 1933 all plots were fallowed.

†Total straw includes straw, cavings and chaff.

*60 years, 1868-1928. ‡ 56 years, 1872-1928. § 75 years, 1853-1928. §§ 69 years, 1859-1928.

CULTIVATIONS, ETC.—Ploughed : Jan. 1-25. Dung applied : Jan. 4. Cultivated : Oct. 1-4, Feb. 23. Harrowed : Feb. 25. Spring-tine harrowed : Feb. 25. Rolled : Feb. 25, Apr. 8. Manures applied : Feb. 8-9. Seed sown : Feb. 25. Variety : Plumage Archer. Harvested : Aug. 4.

FOUR COURSE ROTATION EXPERIMENT, ROTHAMSTED

RESIDUAL VALUES OF ORGANIC AND PHOSPHATIC FERTILIZERS

(For details, see 1932 Report, p. 127)

MANURES APPLIED, SEASON, 1937-8

Treatment	Organic Fertilisers (cwt. per acre)				Additional Artificial Fertilisers (cwt. per acre)		
	Organic Matter	N	P_2O_5	K_2O	N as S of A	P_2O_5 as Super	K_2O as Mur. of Pot.
1	50 (as F.Y.M.)	1.782	1.344†	4.503†	0.018	0	0
2	50 (as Adco)	1.646	1.520†	1.189	0.154	0	1.811
3	123.75 (as straw)	0.862	0.480	2.652	0.938	0.720	0.348
4	None				0.36	1.2	0.6
5	None				0.36	1.2*	0.6

† Exceeded the prescribed limit, so that no additional artificial fertilizer was required.

* As mineral phosphate.

CULTIVATIONS, etc.

	Barley	Ryegrass	Potatoes	Wheat
Variety—	Plumage Archer	Western Wolths	Ally	Yeoman
Date of sowing	Feb. 28	Nov. 3	May 7	Nov. 4
Harvested	Aug. 18	June 18	Oct. 6 and 7	Aug. 11
Previous crop	Potatoes	Barley	Wheat	Ryegrass
Manures applied :—				
Lime	Oct. 20			
Dung, Adco, and accompanying artificials	Nov. 25	Oct. 4	Nov. 25	Oct. 4
Artificials to straw	Nov. 25, Jan. 18, Feb. 21	Oct 5, 6, 7, Jan. 18, Mar. 10	Nov. 27, Jan. 18, May 5	Oct. 6, Jan. 18, Mar. 10
Treatments 4 & 5	Feb. 21	Nov. 2	May 5	Oct. 18
Cultivations—				
Ploughed	Jan. 6-Feb. 4	Oct. 5, 6, 7	Sept. 13, Feb. 4	Oct. 6
Cultivated	Feb. 23		Feb. 23	
Harrowed	Feb. 25, 28	Oct. 12, Nov. 3	Nov. 25, Mar. 7, May 4, June 4	Sept. 27, Nov. 4, Mar. 18
Rolled	Feb. 25, 28, April 8	Oct. 12, Mar. 19	Feb. 25, Mar. 7, May 4, 18, June 3	Mar. 19
Ridged			Mar. 9, May 5, 24, July 23	
Grubbed			July 6, 21	

PLAN AND YIELDS

Rye grass—AH, plots 1-25
Yields in lb., hay

5 43.6 I	2 27.3 IV	1 35.6 II	3 31.3 V	4 49.4 III
5 31.8 III	1 20.4 V	3 24.1 IV	4 44.3 I	2 33.2 II
3 26.8 III	2 27.3 I	5 31.3 V	4 38.6 II	1 32.0 IV
1 26.2 III	3 53.9 I	4 32.0 IV	5 32.7 II	2 32.2 V
4 20.2 V	1 27.7 I	5 27.2 IV	3 27.8 II	2 28.0 III

N.W. ↑

Wheat—AW, plots 26-50
Yields in lb., grain above, straw below

3 60.4 68.1 III	2 67.0 71.0 IV	5 71.0 82.0 V	4 62.1 73.4 II	1 65.8 90.7 I
4 69.7 80.3 IV	2 60.3 69.2 II	1 57.2 68.8 III	5 64.1 74.4 I	3 59.8 68.7 V
1 61.1 74.9 II	4 63.1 71.4 V	3 91.5 107.5 I	5 68.6 80.4 IV	2 57.3 66.7 III
4 79.4 97.6 I	5 66.6 76.9 III	3 64.7 76.8 II	2 58.6 68.9 V	1 63.4 72.6 IV
2 70.7 89.8 I	4 65.9 74.6 III	3 58.3 63.7 IV	1 54.4 62.6 V	5 63.4 69.6 II

Barley—AB, plots 51-75
Yields in lb., grain above, straw below

3 57.4 50.6 IV	4 84.0 62.0 I	1 41.4 40.6 V	2 54.3 53.7 II	5 76.2 75.8 III
3 59.4 53.1 V	4 76.0 66.0 III	5 56.3 64.7 IV	2 55.6 58.9 I	1 60.3 66.2 II
2 57.1 52.9 IV	4 63.9 60.1 V	3 52.9 53.6 III	1 61.2 56.3 I	5 69.9 77.1 II
5 70.2 62.3 V	1 47.2 42.3 IV	3 53.1 55.9 I	4 71.3 67.2 II	2 51.2 56.8 III
4 77.7 59.8 IV	2 42.4 39.6 V	1 34.6 33.9 III	5 65.1 65.4 I	3 65.1 57.9 II

N.W. ↑

Potatoes—AP, plots 76-100
Yields in lb.

4 142 III	2 116 IV	5 116 II	3 82 V	1 170 I
5 107 V	2 157 I	1 144 III	4 112 II	3 176 IV
2 143 II	1 153 IV	5 89 I	4 75 V	3 139 III
2 124 III	4 280 I	1 114 V	5 67 IV	3 165 II
5 121 III	2 115 V	3 289 I	1 142 II	4 141 IV

SUMMARY OF RESULTS, 1938

Manure	Year of Cycle	Wheat cwt. per acre		Potatoes tons per acre	Barley cwt. per acre		Ryegrass cwt. per acre dry matter
		Grain	Straw		Grain	Straw	
Manure as F.Y.M.	I	24.1	33.2	3.25	22.4	20.6	8.2
	II	22.4	27.5	2.72	22.1	24.3	10.9
	III	21.0	25.2	2.75	12.7	12.4	7.9
	IV	23.2	26.6	2.93	17.3	15.5	9.5
	V	19.9	22.9	2.18	15.2	14.9	6.0
Manure as Adco	I	25.9	32.9	3.00	20.4	21.6	8.1
	II	22.1	25.4	2.73	19.9	19.7	9.9
	III	21.0	24.4	2.37	18.8	20.8	8.5
	IV	24.6	26.0	2.22	20.9	19.4	8.1
	V	21.5	25.3	2.20	15.5	14.5	9.6
Manure as Straw	I	33.5	39.4	5.53	21.3	20.5	15.6
	II	23.7	28.1	3.16	23.9	21.2	8.2
	III	22.1	25.0	2.66	19.4	19.6	8.0
	IV	21.4	23.3	3.37	21.0	18.5	7.2
	V	21.9	25.2	1.57	21.8	19.5	9.6
Super.	I	29.1	35.8	5.35	30.8	22.7	13.2
	II	22.8	26.9	2.14	26.1	24.6	11.4
	III	24.2	27.3	2.72	27.9	24.2	14.5
	IV	25.5	29.4	2.70	28.5	21.9	9.5
	V	23.1	26.2	1.43	23.4	22.0	6.0
Rock Phosphate	I	23.5	27.3	1.70	23.9	24.0	12.8
	II	23.2	25.5	2.22	25.6	28.3	9.7
	III	24.4	28.2	2.31	27.9	27.8	9.5
	IV	25.1	29.5	1.28	20.6	23.7	8.3
	V	26.0	30.1	2.05	25.7	22.8	9.4

SIX COURSE ROTATION EXPERIMENT

SEASONAL EFFECTS OF N, P_2O_5 AND K_2O

(For details, see 1932 Report, p. 131)

CULTIVATIONS, Etc.—ROTHAMSTED

	Sugar Beet	Barley	Clover Hay	Wheat	Potatoes	Rye
Variety	Kuhn	Plumage Archer	Montgomery Red	Yeoman	Ally	
Date of sowing	May 9	Feb. 28	April 30, 1937	Nov. 4	April 14	Nov. 4
Harvested	Oct. 26-28	Aug. 2	June 27	Aug. 9	Oct. 1	Aug. 2
Previous crop	Rye	Sugar Beet	Barley	Clover	Wheat	Potatoes
Manures applied	May 9	Feb. 23	Oct, 20 Mar. 14	Oct. 18, Mar. 12	April 12	Nov. 1, Mar. 12
Lime applied		Feb. 25				Oct. 20
Cultivations—						
Ploughed	Aug. 17, Nov. 22	Dec. 7		June 29	Sept. 6, Dec. 16	Oct. 18
Cultivated	Mar. 5			Oct. 16	Mar. 5	
Harrowed	Aug. 18, 24, 30, May 7,9	Feb. 25, 28	April 30, 1937	Oct. 18, 21, Nov. 4, Mar. 18	Mar. 7, June 4	Oct. 18, 21, Nov. 4, Mar. 18
Rolled	Aug. 18, 24, 30, May 4, 7, 9	Feb. 25, April 8	April 30, 1937	Oct. 21, Mar. 19	Mar. 7, May 18, June 3	Oct. 21, Mar. 19
Singled	July 7					
Hoed	June 23, July 16, Aug. 9, 11					
Ridged					Mar. 7, May 24, July 12	
Grubbed					July 5	

CULTIVATIONS, Etc.—WOBURN

	Sugar Beet	Barley	Clover Hay	Wheat	Potatoes	Rye
Variety	Kuhn E	Plumage Archer	Broad Red	Yeoman	Ally	(Home Grown)
Date of sowing	April 12	Mar. 2	May 5, 1937	Nov. 4	April 8	Nov. 4
Harvested	Nov. 3	Aug. 6	July 26, 1937	Aug. 5	Sept. 19-22	Aug. 4
Previous crop	Rye	Sugar beet	Barley	Clover	Wheat	Potatoes
Manures applied	April 12	March 2	Dec. 16, March 18	Nov. 3, March 18	April 7	Nov. 3, March 18
Lime applied		Feb. 21				Oct. 16
Cultivations—						
Ploughed	Aug. 23, March 23	Dec. 30		Sept. 23	Aug. 23, March 22	Sept. 25
Harrowed	Sept. 14, March 31, April 12	March 2, 31	May 5, 1937	Nov. 4, March 16	Oct. 14, March 31, May 20	Nov. 4, March 16
Rolled	Sept. 14, April 12					
Singled	June 14, July 8, 25					
Hoed	July 5			Mar. 28-30	June 22	
Ridged					March 31, July 4	

ROTHAMSTED, 1938

Potatoes—BP, Plots 1-15
Yields in lb.

1N	**3K**	**3P**	**2P**	**0P**
340	353	387	360	301
2K	**0N**	**1K**	**3N**	**4N**
354	268	307	358	401
4K	**0K**	**4P**	**1P**	**2N**
457	361	398	303	350

N ↑

Barley—BB, Plots 16-30
Yields in lb., grain above, straw below

1P	**2K**	**0K**	**1K**	**1N**
84.6	96.0	97.7	99.2	82.6
71.4	80.0	83.3	86.8	70.4
3K	**0P**	**4N**	**3P**	**2P**
95.1	97.7	108.9	95.8	95.2
81.4	81.8	95.1	84.2	79.8
4K	**3N**	**2N**	**0N**	**4P**
105.6	109.2	99.1	71.2	88.0
89.4	92.3	81.9	55.3	72.0

Clover Hay—BC, Plots 31-45
Yields in lb.

0P	**3N**	**3K**	**0N**	**1K**
36.4	50.0	45.3	31.3	41.6
1P	**4N**	**2K**	**2P**	**3P**
25.6	31.2	41.4	40.2	35.5
2N	**1N**	**4K**	**0K**	**4P**
31.4	33.9	61.7	49.0	36.2

N ↑

Wheat—BW, Plots 46-60
Yields in lb., grain above, straw below

1K	**3N**	**4P**	**2P**	**0P**
96.9	101.2	103.0	100.4	100.0
107.1	109.8	120.5	114.6	116.5
4N	**2N**	**0N**	**1P**	**4K**
101.8	103.9	98.5	102.8	96.3
107.2	109.6	110.0	115.7	98.7
0K	**3P**	**1N**	**3K**	**2K**
99.0	108.6	105.4	108.3	102.0
103.0	119.4	121.1	127.7	119.5

Rye—BR, Plots 61-75
Yields in lb., grain above, straw below

2N	**3N**	**4K**	**3K**	**4P**
73.6	82.1	70.4	70.8	67.4
101.4	114.9	104.6	101.2	92.6
1P	**4N**	**0N**	**3P**	**2P**
76.9	81.0	56.9	68.7	73.7
102.1	114.5	81.6	98.8	102.8
0P	**1N**	**2K**	**0K**	**1K**
74.3	59.0	63.4	70.1	69.9
93.7	78.5	84.6	94.4	93.6

N ↑

Sugar Beet—BS, Plots 76-90
Yields in lb., roots (dirty) above, tops centre, sugar percentage below

2N	**3N**	**1N**	**3P**	**3K**
311	335	307	352	310
494	536	446	536	412
16.68	16.30	15.92	16.07	16.18
0K	**1K**	**2P**	**0P**	**1P**
351	403	297	270	259
516	544	466	432	384
16.04	16.39	16.07	16.16	15.55
4N	**0N**	**4P**	**2K**	**4K**
379	330	323	284	235
627	478	486	400	293
15.32	16.39	15.58	16.33	15.55

WOBURN, 1938

Rye—CR, Plots 1-15
Yields in lb., grain above, straw below

0K	2P	1P	0P	1N
42.5	61.0	54.2	52.2	46.2
50	74	67	60	56
1K	3P	3N	3K	0N
57.0	55.2	75.3	54.0	44.2
68	64	85	64	52
4P	2N	4N	4K	2K
50.5	54.2	67.0	59.4	41.1
64	61	82	74	56

N.W. ↑

Sugar Beet—CS, Plots 16-30
Yields in lb., roots (dirty) above, tops centre, sugar percentage below

0N	3P	2K	1P	0K
473	542	614	564	488
252	289	376	319	244
17.77	17.89	18.23	18.36	17.83
4P	2P	4K	3N	2N
568	476	564	644	540
308	292	376	400	350
18.26	18.26	18.49	18.26	18.46
1N	0P	3K	1K	4N
483	488	578	563	591
239	319	371	388	428
18.49	17.92	18.75	18.95	18.00

Potatoes—CP, Plots 31-45
Yields in lb.

1K	2P	1P	4N	4K
452	492	466	612	574
3P	0K	3N	3K	0N
511	462	506	552	430
4P	0P	2N	2K	1N
440	340	374	458	448

N.W. ↑

Clover Hay—CC, Plots 46-60
Yields in lb., green weights

4K	3K	1K	3N	3P
89	139	120	120	89
0P	1P	4N	1N	2P
88	108	118	150	136
2K	0K	2N	4P	0N
92	94	122	164	156

Barley—CB, Plots 61-75
Yields in lb., grain above, straw below

4N	3N	0N	2K	1K
91.2	92.0	63.0	95.0	93.5
73	73	52	81	83
2N	0P	3K	4P	3P
93.0	94.2	105.7	102.7	106.0
71	78	85	95	109
1P	1N	4K	2P	0K
88.2	90.7	98.2	93.2	95.0
75	70	83	89	87

N.W. ↑

Wheat—CW, Plots 76-90
Yields in lb., grain above, straw below

3P	4P	2K	3K	4N
77.5	78.7	89.2	94.2	89.2
88	91	105	114	109
0N	2P	1P	3N	2N
70.2	91.0	97.5	92.5	89.7
79	103	117	110	111
1N	4K	0P	0K	1K
70.2	83.7	89.5	76.7	85.0
79	96	101	88	99

ROTHAMSTED, 1938

1.—Mean yields per acre and increments in yield per cwt. of N, P_2O_5 and K_2O.

		Average 1930-37	1938	Standard errors, 1938			Average 1930-37	1938	Standard errors, 1938
Sugar Beet Roots (washed) tons	Yield	7.55	4.65		**Clover Hay** Dry matter cwt.	Yield	19.7*	11.7	
	N	1.79	1.19			N	12.0*	3.3	±4.9
	P	−0.40	1.76			P	0.3*	1.7	±4.9
	K	0.21	−1.80			K	2.4*	3.4	±2.9
Tops tons	Yield	8.35	8.39		**Wheat** Grain cwt.	Yield	23.6	36.4	
	N	3.60	**4.62**	±1.67		N	3.6†	0.6	±3.1
	P	−1.24	3.10	±1.67		P	0.1	2.9	±3.1
	K	−0.39	**−4.12**	±1.00		K	1.1	0.8	±1.9
Sugar percentage	Mean	17.14	16.04		Straw cwt.	Yield	46.3	40.5	
	N	−0.31	−1.17			N	21.6†	−4.1	
	P	−0.48	−0.43			P	2.7	2.7	
	K	0.47	−0.48			K	2.2	1.7	
Total sugar cwt.	Yield	26.4	14.9		**Potatoes** tons	Yield	6.52	6.22	
	N	5.8	2.6	±4.1		N	1.67	**3.33**	±1.13
	P	−2.2	5.3	±4.1		P	1.01	**3.27**	±1.13
	K	1.6	**−6.2**	±2.5		K	2.43	**1.68**	±0.68
Barley Grain cwt.	Yield	28.0	33.9		**Rye** Grain cwt.	Yield	22.4§	25.2	
	N	6.5	**24.3**	±4.1		N	5.2§	**16.9**	±2.7
	P	3.4	−2.0	±4.1		P	1.5§	−5.2	±2.7
	K	0.4	1.7	±2.4		K	−1.0§	0.2	±1.6
Straw cwt.	Yield	35.6	28.7		Straw cwt.	Yield	43.6§	34.7	
	N	13.7	24.2			N	16.2§	24.4	
	P	5.0	−1.6			P	4.4§	−1.3	
	K	4.5	0.9			K	3.6§	4.0	

* Crop failed in 1933 and 1935. † 1931-37. § 1934-37. Significant results in heavy type. Negative sign means depression.

2.—Average percentage increments in yield for each application of N, P_2O_5 and K_2O.

	N		P		K		Standard errors, 1938
	Average 1930-37	1938	Average 1930-37	1938	Average 1930-37	1938	
Sugar Beet							
Roots (washed)	3.04	3.83	−0.52	5.68	1.08	−9.66	
Tops	6.74	**8.26**	−2.15	5.54	−0.53	**−12.29**	±2.99
Sugar percentage	0.02	−1.10	−0.30	−0.40	0.68	−0.74	
Total sugar	2.75	2.62	−0.96	5.37	1.81	**−10.40**	±4.17
Barley—Grain	3.75	**10.75**	1.85	−0.88	0.50	1.24	±1.80
Straw	5.79	12.65	2.34	−0.84	3.28	0.80	
Clover Hay—Dry matter	8.04*	4.20	−2.23*	2.14	2.04*	7.29	±6.26
Wheat—Grain	3.11†	0.25	0.03	1.18	0.94	0.58	±1.27
Straw	7.71†	−1.51	0.73	1.01	1.02	1.06	
Potatoes	3.82	**8.05**	2.37	**7.88**	9.37	**6.76**	±2.73
Rye—Grain	3.68§	**10.08**	1.10§	−3.10	−1.30§	0.20	±1.63
Straw	6.41§	10.54	1.30§	−0.58	−2.08§	2.91	

* Crop failed in 1933 and 1935. † 1931-1937. § 1934-1937. Significant results in heavy type. Negative sign means depression.

WOBURN, 1938

1.—Mean yields per acre and increments in yield per cwt. of N, P_2O_5 and K_2O.

		Average 1930-37	1938	Standard errors, 1938			Average 1930-37	1938	Standard errors, 1938
Sugar Beet Roots (washed) tons	Yield	7.44	7.89		**Clover Hay** Dry matter cwt.	Yield	27.7*	17.9	
	N	3.50	2.51			N	−10.0*	−10.6	±7.2
	P	0.45	1.65			P	−4.9*	13.3	±7.2
	K	0.39	2.32			K	4.8*	0.5	±4.3
Tops tons	Yield	6.43	5.89		**Wheat** Grain cwt.	Yield	12.5†	30.4	
	N	2.29	**6.10**	±1.36		N	14.0†	**14.3**	±4.8
	P	0.94	−0.63	±1.36		P	−1.4†	−9.9	±4.8
	K	1.00	1.76	±0.82		K	−0.1†	3.3	±2.9
Sugar percentage	Mean	17.05	18.26		Straw cwt.	Yield	26.0†	35.5	
	N	−1.00	0.15			N	31.2†	21.7	
	P	0.48	0.14			P	−2.5†	−11.7	
	K	0.70	0.45			K	−1.4†	4.4	
Total Sugar cwt.	Yield	25.5	28.8		**Potatoes** tons	Yield	8.12	8.48	
	N	10.5	9.2	±5.9		N	4.46	**5.00**	±2.17
	P	2.3	6.2	±5.9		P	0.66	2.93	±2.17
	K	2.3	**9.1**	±3.5		K	0.73	2.32	±1.30
Barley Grain cwt.	Yield	23.5	33.4		**Rye** Grain cwt.	Yield	20.4§	19.4	
	N	18.6	**13.9**	±5.6		N	13.7§	**17.7**	±5.2
	P	0.9	8.4	±5.6		P	−2.3§	−0.6	±5.2
	K	1.2	2.7	±3.3		K	−1.6§	4.4	±3.1
Straw cwt.	Yield	37.8	28.7		Straw cwt.	Yield	35.2§	23.3	
	N	19.6	10.7			N	30.0§	21.2	
	P	0.8	16.1			P	−3.4§	1.3	
	K	2.9	−0.9			K	−2.3§	6.2	

* 1934, crop failed. † 1931-1937. § 1934-1937. Significant results in heavy type. Negative sign means depression.

2.—Average percentage increments in yield for each application of N, P_2O_5 and K_2O.

	N		P		K		Standard errors, 1938
	Average 1930-37	1938	Average 1930-37	1938	Average 1930-37	1938	
Sugar Beet—							
Roots (washed)	6.36	4.77	0.68	3.13	1.98	7.36	
Tops	5.01	**15.53**	2.33	−1.60	3.41	7.45	±3.47
Sugar percentage	−0.65	0.13	0.40	0.11	1.02	0.61	
Total sugar	5.53	4.79	1.05	3.23	2.87	**7.91**	±3.08
Barley—Grain	12.42	**6.26**	0.48	3.77	1.75	2.04	±2.50
Straw	8.45	5.61	0.58	8.41	1.53	−0.77	
Clover Hay—Dry matter	−7.32*	−8.86	−1.42*	11.09	6.73*	0.67	±6.00
Wheat—Grain	15.80†	**7.08**	−1.96†	−4.91	1.22†	2.70	±2.36
Straw	18.39†	9.16	−1.80†	−4.96	0.98†	3.13	
Potatoes	9.03	**8.85**	1.11	5.19	2.02	6.84	±3.85
Rye—Grain	10.46§	**13.72**	−1.53§	−0.46	−1.99§	5.62	±3.99
Straw	12.96§	13.66	−1.51§	0.86	−1.68§	6.70	

* 1934 crop failed. † 1931-1937. § 1934-1937. Significant results in heavy type. Negative sign means depression.

THREE COURSE ROTATION EXPERIMENT, ROTHAMSTED, 1938

EFFECT OF PLOUGHING IN STRAW

(For details, see 1933 Report, p. 118)

CULTIVATIONS, Etc.

	Barley	Sugar Beet	Potatoes
Variety	Plumage Archer	Kuhn	Ally
Date of Sowing ..	Feb. 28	May 10	April 14
Harvested.. ..	Aug. 5	Oct. 25	Oct. 10
Previous crop ..	Potatoes	Barley	Sugar Beet
Manures applied—			
Artificials ..	Dec. 15	Dec. 15, May 9	Dec. 15, April 13
Adco and straw	Dec. 15	Dec. 15	Dec. 15
Cultivations—			
Ploughed ..	Dec. 15-28	Dec. 15-28	Dec. 15-28
Cultivated ..	Feb. 24	Sept. 16, 30, Feb. 24	Feb. 24
Harrowed ..	Feb. 28	Oct. 5, May 9, 10	Mar. 7, June 4
Rolled	Feb. 28, April 8	May 4, 9, 10	Mar. 7, May 18
Singled		July 8	
Hoed		June 23, July 16, Aug. 8, 10	
Ridged ..			Mar. 8, May 26, July 11
Grubbed ..			July 4

The comparisons of winter green-manure crops of vetches and rye, made in previous years of the experiment, have been discontinued.

PLAN AND YIELDS

Barley—DB, Plots 49-72. Yields in lb., grain above, straw below.

St *1* I 81.5 73.5	**Ad I** 85.4 76.1	**Ad II** 82.8 68.2	**Ad I** 83.3 68.7	**Ad II** 64.0 66.0	**St *1* I** 57.8 58.7
St *1* I 92.7 76.3	**St *2* II** 98.5 87.0	**St *1* II** 95.7 83.3	**St *2* I** 95.6 79.9	**St *2* I** 79.9 71.1	**St *2* I** 71.0 64.0
Ar I 89.4 74.1	**Ar II** 98.7 81.3	**Ar I** 89.6 70.4	**Ad I** 85.3 68.7	**St *1* II** 88.7 78.3	**Ar II** 91.6 76.9
St *1* II 90.6 81.4	**Ad II** 79.1 67.9	**St *2* II** 91.0 78.5	**St *2* II** 93.2 79.3	**Ar I** 84.0 72.0	**Ar II** 85.8 76.7

Sugar Beet—DS, Plots 25-48. **Yields in lb., roots (dirty) above, tops centre, sugar percentage below.**

St *1* II 399 466 16.79	**Ad I** 345 410 17.34	**Ad II** 307 398 17.05	**Ar II** 342 475 16.91	**Ar I** 256 359 17.02	**St *2* I** 342 446 17.66
St *2* II 380 450 17.66	**Ad II** 352 418 17.66	**St *2* I** 331 406 17.28	**St *2* I** 362 442 16.76	**St *1* II** 372 504 16.39	**Ar I** 322 382 17.89
Ar II 282 420 16.04	**Ad II** 317 428 15.95	**St *2* II** 363 509 16.65	**St *1* I** 353 430 17.19	**St *1* I** 328 400 17.10	**Ad I** 293 342 16.99
Ad I 250 356 15.69	**Ar I** 279 358 15.92	**St *1* I** 333 402 16.21	**Ar II** 269 408 15.64	**St *2* II** 337 416 16.82	**St *1* II** 382 484 16.53

Potatoes—DP. **Plots 1-24.** **Yields in lb.**

St *1* II 459	**St *2* I** 355	**Ar I** 339	**St *2* II** 436	**Ar II** 418	**Ad I** 418
St *1* I 358	**St *2* II** 445	**St *1* II** 460	**Ar II** 417	**Ad II** 344	**St *2* I** 382
Ar II 444	**St *2* II** 456	**Ar I** 289	**St *1* I** 339	**Ad I** 305	**St *1* II** 438
Ad II 403	**Ar I** 301	**Ad I** 293	**St *2* I** 359	**St *1* I** 338	**Ad II** 287

SUMMARY OF RESULTS

	Manured 1937-8					Manured 1936-7				
	Artificials	Adco	Straw St 1	Straw St 2	*Mean*	Artificials	Adco	Straw St 1	Straw St 2	*Mean*
Barley—										
Grain cwt. p.a. ..	41.1	33.6	40.9	42.1	*39.4*	39.1	37.8	34.5	36.7	*37.0*
Straw cwt. p.a. ..	34.9	30.1	36.2	36.4	*34.4*	32.2	31.8	31.0	32.0	*31.8*
Sugar Beet—										
Roots (washed) tons p.a.	5.62	5.95	7.12	6.77	*6.36*	5.27	5.56	6.36	6.36	*5.89*
Tops tons p.a. ..	9.69	9.25	10.82	10.23	*10.00*	8.18	8.24	9.17	9.63	*8.80*
Sugar percentage ..	16.20	16.89	16.57	17.04	*16.68*	16.94	16.67	16.83	17.23	*16.92*
Total sugar cwt. p.a.	18.3	20.1	23.6	23.1	*21.3*	17.9	18.6	21.4	22.0	*20.0*
Potatoes—										
Tons p.a.	9.52	7.69	10.10	9.96	*9.32*	6.91	7.56	7.71	8.15	*7.58*

LONG PERIOD CULTIVATION EXPERIMENT, 1937

Long Hoos V
(For details, see 1934 Report, p. 175)

CULTIVATIONS, Etc.

	Wheat	Mangolds	Barley
Variety	Victor	Yellow Globe	Plumage Archer
Date of sowing	Nov. 17	May 27	Mar. 9
Harvested	Aug. 11	Nov. 2-4	Aug. 18
Previous crop	Barley	Wheat	Mangolds
Manures applied—			
Cyanamide	Mar. 17	May 21	Mar. 2
Nitro-chalk	Mar. 15	May 21, July 27	Mar. 2
Super. & mur. pot. . .		May 21	
Cultivations—			
Ploughed	Sept. 10	Feb. 2	Feb. 2-4
Cultivated	Sept. 23	Sept. 15, 30, Feb. 14	Feb. 5-14
Simared*	Nov. 11	May 19	Feb. 22
Harrowed	Nov. 11, 17, Mar. 18	Oct. 5, 18, May 23, 27	Mar. 7, 9
Hoed		June 29, July 18, Aug. 9, 10	
Rolled	Mar. 19	May 18, 19, 23	May 19
Singled		July 8	

* Simared or rotary cultivated.

PLAN AND YIELDS IN LB.

Barley

Grain Left, Straw Right

1	P Sh Cy	16.7	25.8		C Sh N	15.6	22.9	73
	P D Cy	19.8	23.7		S Sh N	28.1	30.4	
	S Sh N	31.6	28.9		S D Cy	24.2	26.8	
	C D N	33.6	30.9		P Sh Cy	14.9	25.6	
	S D Cy	30.9	26.1		S D N	23.1	26.4	
B	C Sh N	36.4	31.6		P Sh N	19.1	26.9	A
	S Sh Cy	28.0	25.5		P D N	18.5	27.0	
	C D Cy	33.1	27.9		S Sh Cy	27.5	31.5	
	C Sh Cy	35.8	31.7		C Sh Cy	22.4	28.1	
	S D N	37.3	32.7		C D N	26.0	31.5	
	P D N	30.3	29.3	N	C D Cy	19.8	29.7	
	P Sh N	37.3	27.2	↑	P D Cy	19.0	27.0	
	C Sh N	35.8	27.2		C D Cy	22.6	29.4	
	S Sh Cy	32.7	26.8		P Sh Cy	22.1	29.4	
	P D Cy	33.4	30.6		S D Cy	32.6	32.4	
	C D Cy	35.7	28.8		P D Cy	25.1	31.9	
	C Sh Cy	37.1	31.4		S Sh N	30.4	27.1	
C	P Sh Cy	37.3	31.7		C Sh Cy	25.7	30.8	C
	S Sh N	36.7	30.8		S D N	28.2	28.8	
	C D N	33.5	29.0		C D N	19.7	22.3	
	S D N	33.1	26.4		P Sh N	29.4	32.1	
	P Sh N	37.8	30.2		P D N	25.2	28.8	
	S D Cy	34.2	28.3		S Sh Cy	28.2	27.3	
	P D N	20.9	19.1		C Sh N	20.8	23.7	

Mangolds

Roots Left, Tops Right

	S Sh N	232	99
	C Sh N	230	106
	C Sh Cy	228	105
	P D N	280	127
	C D N	233	100
C	P Sh Cy	246	100
	C D Cy	238	102
	S D Cy	238	90
	P Sh N	246	112
	S Sh Cy	224	81
	S D N	278	100
	P D Cy	262	121
	S D Cy	225	90
	P Sh N	228	118
	P Sh Cy	232	118
	P D Cy	252	124
	C Sh Cy	228	120
A	S Sh Cy	247	102
	C Sh N	215	110
	C D Cy	265	112
	P D N	208	114
	C D N	208	105
	S Sh N	231	107
	S D N	260	106

S Sh N	236	106	
S D Cy	254	86	
P Sh Cy	275	107	
P Sh N	262	130	
P D Cy	310	130	
C D Cy	262	100	C
S D N	288	106	
P D N	280	138	
S Sh Cy	204	79	
C Sh N	235	114	
C D N	218	112	
C Sh Cy	205	100	
S D N	242	107	
S Sh N	215	108	
P D Cy	209	107	
C D N	210	113	
P D N	227	134	
P Sh Cy	197	100	B
S Sh Cy	204	98	
C Sh N	238	120	
C D Cy	210	98	
C Sh Cy	182	94	
S D Cy	222	95	
P Sh N	214	116	

Wheat

Grain Left, Straw Right

	C Sh N	10.6	14.4
	S Sh N	14.8	19.7
	P Sh Cy	26.9	30.1
	C D Cy	23.6	26.4
	C Sh Cy	20.5	25.5
C	C D N	24.7	29.8
	S Sh Cy	14.4	19.1
	S D Cy	17.9	23.6
	P D Cy	23.3	27.7
	P Sh N	31.2	35.8
	P D N	29.5	33.5
	S D N	18.0	25.0
	S D Cy	18.8	22.2
	C Sh Cy	20.9	25.6
	C D Cy	18.0	22.0
	P D Cy	35.1	36.4
	C D N	23.4	28.1
B	S D N	17.7	21.3
	C Sh N	19.0	22.5
	P Sh Cy	25.1	24.9
	S Sh N	14.1	18.9
	P Sh N	29.5	33.0
	S Sh Cy	11.1	15.9
72	P D N	31.8	34.7

C D Cy	11.7	14.8	
C Sh Cy	17.3	21.7	
C D N	27.3	33.2	
P Sh N	30.1	32.4	
C Sh N	19.7	23.3	
S D Cy	19.5	23.5	A
S Sh N	17.0	25.0	
P D Cy	27.6	31.4	
S Sh Cy	14.5	21.0	
P Sh Cy	25.1	27.9	
P D N	30.0	32.0	
S D N	17.2	24.3	
S D Cy	13.8	20.2	
C D Cy	18.5	22.5	
C Sh Cy	17.2	18.8	
P Sh N	26.2	30.8	
C D N	17.8	25.2	
S Sh N	13.4	20.1	C
S D N	10.8	18.2	
S Sh Cy	12.7	17.3	
P D Cy	23.0	27.5	
P D N	23.5	28.0	
C Sh N	19.8	24.7	
P Sh Cy	27.9	29.6	144

Summary of Results

	Continuous				Cycle A			Cycle B			
Last year	P	S	C	*Mean*	C	P	S	S	C	P	*Mean*
This year	P	S	C		P	S	C	P	S	C	
Wheat				GRAIN : cwt. per acre							
N D ..	15.4	8.4	12.3	*12.0*	17.4	10.0	15.8	18.5	10.3	13.6	*14.3*
Sh ..	16.7	8.2	8.8	*11.2*	17.5	9.9	11.4	17.1	8.2	11.0	*12.5*
Cy D ..	13.4	9.2	12.2	*11.6*	16.0	11.3	6.8	20.4	10.9	10.4	*12.6*
Sh ..	15.9	7.9	10.9	*11.6*	14.6	8.4	10.0	14.6	6.4	12.1	*11.0*
St. Errors		±1.32		*±0.759*							
				STRAW : cwt. per acre							
N D ..	17.8	12.5	16.0	*15.4*	18.6	14.1	19.3	20.1	12.4	16.3	*16.8*
Sh ..	19.3	11.5	11.3	*14.0*	18.8	14.5	13.5	19.2	11.0	13.1	*15.0*
Cy D ..	16.0	12.7	14.2	*14.3*	18.2	13.6	8.6	21.1	12.9	12.8	*14.5*
Sh ..	17.3	10.6	12.9	*13.6*	16.2	12.2	12.6	14.5	9.2	14.9	*13.3*
Mangolds				ROOTS : tons per acre							
N D ..	16.25	16.42	13.09	*15.25*	12.07	15.09	12.07	13.17	14.04	12.19	*13.11*
Sh ..	14.74	13.58	13.49	*13.94*	13.23	13.41	12.48	12.42	12.48	13.81	*12.97*
Cy D ..	16.60	14.28	14.51	*15.13*	14.62	13.06	15.38	12.13	12.88	12.19	*13.38*
Sh ..	15.12	12.42	12.56	*13.37*	13.46	14.33	13.23	11.43	11.84	10.56	*12.48*
St. Errors		±0.605		*±0.349*							
				TOPS : tons per acre							
N D ..	7.69	5.98	6.15	*6.61*	6.62	6.15	6.09	7.78	6.21	6.56	*6.57*
Sh ..	7.02	5.95	6.38	*6.45*	6.85	6.21	6.38	6.73	6.27	6.96	*6.57*
Cy D ..	7.28	5.11	5.86	*6.08*	7.20	5.22	6.50	6.21	5.51	5.69	*6.06*
Sh ..	6.01	4.64	5.95	*5.53*	6.85	5.92	6.96	5.80	5.69	5.46	*6.11*
Barley				GRAIN : cwt. per acre							
N D ..	13.4	17.8	15.4	*15.5*	10.7	13.4	15.1	17.6	21.6	19.5	*16.3*
Sh ..	19.5	19.5	16.4	*18.5*	11.1	16.3	9.1	21.6	18.3	21.1	*16.2*
Cy D ..	17.0	19.4	16.9	*17.8*	11.0	14.0	11.5	11.5	17.9	19.2	*14.2*
Sh ..	17.2	17.7	18.2	*17.7*	8.6	16.0	13.0	9.7	16.2	20.8	*14.0*
St. Errors		±1.73		*±0.999*							
				STRAW : cwt. per acre							
N D ..	13.9	16.0	14.9	*14.9*	15.7	15.3	18.3	16.9	19.0	17.9	*17.2*
Sh ..	18.1	16.8	14.8	*16.6*	15.6	17.6	13.3	15.8	16.8	18.3	*16.2*
Cy D ..	18.1	17.6	16.9	*17.5*	15.7	15.6	17.2	13.8	15.1	16.2	*15.6*
Sh ..	17.7	15.7	18.0	*17.1*	14.9	18.3	16.3	15.0	14.8	18.4	*16.3*

Mean of Nitro-Chalk and Cyanamide

	Continuous				Cycle A			Cycle B			
Last year	P	S	C	*Mean*	C	P	S	S	C	P	*Mean*
This year	P	S	C		P	S	C	P	S	C	
Wheat	GRAIN : cwt. per acre										
D	14.4[1]	8.8[1]	12.2[1]	*11.8*[3]	16.7	10.6	11.3	19.4	10.6	12.0	*13.4*
Sh	16.3[1]	8.0[1]	9.8[1]	*11.4*[3]	16.0	9.2	10.7	15.8	7.3	11.6	*11.7*
Mean ..	*15.4*[2]	*8.4*[2]	*11.0*[2]	*11.6*	*16.4*	*9.9*	*11.0*	*17.6*	*9.0*	*11.8*	*12.6*
	St. Errors (1) ±0.930, (2) ±0.658, (3) ±0.537.										
	STRAW : cwt. per acre										
D	16.9	12.6	15.1	*14.9*	18.4	13.8	14.0	20.6	12.6	14.6	*15.7*
Sh	18.3	11.0	12.1	*13.8*	17.5	13.4	13.0	16.8	10.1	14.0	*14.1*
Mean ..	*17.6*	*11.8*	*13.6*	*14.3*	*18.0*	*13.6*	*13.5*	*18.7*	*11.4*	*14.3*	*14.9*
Mangolds	ROOTS : tons per acre										
D	16.42[1]	15.35[1]	13.80[1]	*15.19*[3]	13.34	14.08	13.72	12.65	13.46	12.19	*13.24*
Sh	14.93[1]	13.00[1]	13.02[1]	*13.65*[3]	13.34	13.87	12.86	11.92	12.16	12.18	*12.72*
Mean ..	*15.68*[2]	*14.18*[2]	*13.41*[2]	*14.42*	*13.34*	*13.98*	*13.29*	*12.28*	*12.81*	*12.19*	*12.98*
	St. Errors (1) ±0.428, (2) ±0.303, (3) ±0.247.										
	TOPS : tons per acre										
D	7.48	5.54	6.00	*6.34*	6.91	5.68	6.30	7.00	5.86	6.12	*6.31*
Sh	6.52	5.30	6.16	*5.99*	6.85	6.06	6.67	6.26	5.98	6.21	*6.34*
Mean ..	*7.00*	*5.42*	*6.08*	*6.17*	*6.88*	*5.87*	*6.48*	*6.63*	*5.92*	*6.16*	*6.32*
Barley	GRAIN : cwt. per acre										
D	15.2[1]	18.6[1]	16.2[1]	*16.7*[3]	10.8	13.7	13.3	14.6	19.8	19.4	*15.3*
Sh	18.4[1]	18.6[1]	17.3[1]	*18.1*[3]	9.8	16.2	11.0	15.6	17.2	21.0	*15.1*
Mean ..	*16.8*[2]	*18.6*[2]	*16.8*[2]	*17.4*	*10.3*	*15.0*	*12.2*	*15.1*	*18.5*	*20.2*	*15.2*
	St. Errors (1) ±1.22, (2) ±0.863, (3) ±0.704.										
	STRAW : cwt. per acre										
D	16.0	16.8	15.9	*16.2*	15.7	15.4	17.8	15.4	17.0	17.0	*16.4*
Sh	17.9	16.2	16.4	*16.8*	15.2	18.0	14.8	15.4	15.8	18.4	*16.3*
Mean ..	*17.0*	*16.5*	*16.2*	*16.6*	*15.4*	*16.7*	*16.3*	*15.4*	*16.4*	*17.7*	*16.3*

Conclusions

For wheat grain the mean yields of the plots ploughed, simared and cultivated every year were respectively 15.4, 8.4 and 11.0 cwt. per acre, all differences being significant. The results were similar with the rotating cultivations.

For barley grain there were no significant differences between the effects of the continuous cultivations. On the blocks with rotating cultivations the yields varied irregularly, the plots ploughed this year giving the lowest yields in each case.

For mangold roots the plots ploughed every year gave a significantly higher yield than the plots simared every year, the latter being slightly but not significantly above the plots cultivated every year. With the rotating cultivations the differences between ploughing, simaring and cultivating this year were small.

For mangold roots the deep cultivations gave a significantly higher yield than the shallow cultivations on the continuous part of the experiment. The results with the rotating cultivations were in the same direction though the difference was small. For wheat grain there was little difference between deep and shallow cultivations on the continuous plots, but deep cultivation gave significantly higher yields on the rotating cycles. There were no significant differences between the effects of deep and shallow cultivation on barley grain.

There was no apparent difference between nitro-chalk and cyanamide.

NEW GREEN MANURING EXPERIMENT

STACKYARD, WOBURN

(For details see 1936 Report, p. 203)

Cultivations, etc.

UPPER HALF: Ploughed: Sept. 27-29. Harrowed, mustard and tares drilled: Oct. 21. Ploughed: March 18. Harrowed, mustard and tares redrilled: March 28. Clover and ryegrass cut: June 17. Dung applied: June 24. Straw applied: July 1. Ploughed: 1-4. Rolled, harrowed, kale drilled and sulphate of ammonia applied to all plots: July 7 and 8. Mineral manures applied to all plots and harrowed: July 9. Kale redrilled: Aug. 11 and 12. Hoed: Aug. 30, Sept. 5, 14 and 20. Harvested: Feb. 13 and 20. Variety: Thousand head. Previous crop: Barley.

LOWER HALF: Ploughed: Feb. 2-4. Harrowed and barley drilled: March 3. Harrowed and Broad Red Clover and Italian Ryegrass drilled: March 31. Harvested: Aug. 11 and 12. Variety: Plumage Archer. Previous crop: Kale.

SPECIAL NOTE: The green manuring crops on the upper half sown in the winter (Oct. 21) were a failure.

W—STACKYARD, 1938

Upper half—Kale. Plan and yields in lb.

20	C	—	—	N	84	T	D	S	2N	144	40
	M	—	—	N	73	R	—	—	N	11	
	F	—	S	2N	171	F	—	—	2N	43	
	M	—	S	2N	174	M	D	S	N	82	
	T	D	S	N	239	F	D	—	2N	166	
	T	—	—	N	212	C	D	—	2N	171	
	C	D	S	2N	301	T	—	S	N	40	
	R	D	—	2N	378	F	D	S	N	89	
	C	—	S	N	335	C	—	S	2N	174	
	R	—	S	2N	230	F	—	—	N	49	
	F	D	—	N	318	R	D	S	N	179	
	M	—	—	2N	295	F	D	S	2N	297	
	C	D	—	N	303	T	D	—	N	212	
	F	—	S	N	270	R	—	S	N	20	
	C	—	—	2N	325	M	—	S	N	40	
	R	D	S	2N	298	M	D	—	N	143	
	T	—	S	2N	288	M	D	S	2N	179	
	C	D	S	N	313	T	—	—	2N	139	
	R	—	—	2N	224	R	D	—	N	158	
1	M	D	—	2N	268	T	D	—	2N	322	21

Lower half—Barley. Plan and yields of grain in lb.

20	C	D	S	N	110	R	—	S	2N	94	40
	M	D	—	2N	106	M	—	S	N	118	
	F	D	—	2N	104	F	—	—	N	94	
	T	—	S	N	83	R	D	—	N	95	
	T	D	—	2N	95	T	D	S	2N	102	
	F	D	S	N	119	F	—	S	2N	94	
	F	D	S	2N	105	R	D	S	N	99	
	T	—	S	2N	95	F	—	—	2N	86	
	R	—	S	N	69	C	D	—	2N	101	
	T	D	—	N	98	R	—	—	2N	80	
	M	—	—	N	78	T	—	—	2N	84	
	F	—	S	N	73	M	—	S	2N	75	
	C	—	S	2N	99	F	D	—	N	81	
	R	—	—	N	99	C	D	S	2N	87	
	R	D	S	2N	106	M	D	S	N	91	
	T	—	—	N	91	C	—	S	N	94	
	M	D	—	N	104	R	D	—	2N	99	
	M	—	—	2N	106	C	—	—	2N	85	
	T	D	S	N	121	M	D	S	2N	84	
1	C	D	—	N	106	C	—	—	N	79	21

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Upper half : Leys and Green Manures : dry matter and nitrogen per cent.

	Fallow	Tares	Mustard	Clover	Ryegrass
	Winter crop : buried			Dry matter : carted off	
Dry matter, cwt. ..	0.2	1.1	0.3	13.8	6.4
Nitrogen per cent. ..	3.64	2.88	3.27	4.12	1.18
	Spring crop : buried			Stubble : buried	
Dry matter, cwt. ..	2.2	23.3	13.4	44.9	44.6
Nitrogen per cent. ..	3.12	1.99	1.16	2.15	0.51

Note.—The dry matter yields for the individual plots are also available. The fallow figures are the weights and nitrogen percentages of the weeds on the plots.

Lower half : barley grain, cwt. per acre

Residual effects of green manures and fertilizers applied to kale in 1937

Leys and green manures prior to kale crop of 1937. Ley sown 1938 under barley.	None None	Tares None	Clover Ryegrass	Mustard None	Ryegrass Clover	*Mean* (±*0.789*)	*Increase* (±*1.11*)
No dung	21.1	21.4	21.7	22.9	20.8	*21.6*	
Dung	24.9	25.3	24.6	23.4	24.3	*24.5*	+*2.9*
No straw	22.2	22.4	22.6	24.0	22.8	*22.8*	
Straw	23.7	24.3	23.7	22.4	22.4	*23.3*	+*0.5*
2 cwt. sulphate of amm.	22.3	23.8	23.6	23.8	22.0	*23.1*	
4 cwt. sulphate of amm.	23.6	22.9	22.6	22.6	23.1	*23.0*	−*0.1*
Mean (±*1.25*)	*23.0*	*23.3*	*23.1*	*23.2*	*22.6*	*23.0*	

Interactions of fertilizers
Grain, cwt. per acre (±1.58)

	2 cwt. sulphate of amm. No dung	2 cwt. sulphate of amm. Dung	4 cwt. sulphate of amm. No dung	4 cwt. sulphate of amm. Dung
No straw ..	21.5	23.6	21.5	24.6
Straw ..	21.2	26.3	22.2	23.5

Conclusions

Upper half :—

The kale crop was a failure, the mean yield being just over 2 tons per acre and for that reason no summary tables are given. There were no significant effects of the green manures or leys. Dung produced a significant increase of 0.83 tons per acre and sulphate of ammonia a significant increase of 0.86 tons per acre.

Lower half :—

There were no effects on the yield of barley grain of the green manures grown before the preceding kale crop, or of the undersowing of clover or ryegrass.

Dung applied to the kale increased the yield of barley grain significantly by 2.9 cwt. per acre. The residual effects of sulphate of ammonia and straw were negligible.

EXPERIMENT TO COMPARE LEY AND ARABLE ROTATIONS, WOBURN

Stackyard, Series D

The purpose of the experiment is to test the value of a three year ley, three years of lucerne and an arable rotation with a one year ley, as means of building up soil fertility in comparison with a rotation without leys. The effects of these crop sequences are measured by the yields of two following crops of potatoes and barley, which may be termed the indicator crops. Each rotation therefore has five courses.

Rotations

The rotations compared are :—

(1) Three year ley,
(2) Three years of lucerne,
(3) Potatoes, wheat, one year ley,
(4) Potatoes, wheat, kale,

potatoes, barley.

Arrangement

The plan of the experiment is shown on p.138 and the cropping sequence on p.137.

There are five blocks, one for each phase of the five year cycle, so that all the courses of every rotation are represented every year. The rotations begin on block 3 in 1938, and then in successive years on blocks 5, 4, 2, and 1. Each block has eight main plots, two for each rotation. On half the plots the same rotation will continue throughout the experiment. This may cause wide fertility differences if the repeated arable cropping should lead to organic matter shortage. On the remaining plots the ley and arable rotations will alternate so as to provide comparisons at a steadier fertility level. This alternation of rotations can be made in two ways, namely, 1, 3, 2, 4 etc. and 1, 4, 2, 3 etc. The following sequences were chosen :

Cycle	Blocks 1, 3, 4 Sequence of Rotations				Blocks 2, 5 Sequence of Rotations			
1	1	2	3	4	1	2	3	4
2	3	4	1	2	4	3	2	1
3	2	1	4	3	2	1	4	3
4	4	3	2	1	3	4	1	2

Thus, in blocks 1, 3 and 4 the plots carrying rotation 1 in the first cycle will carry rotation 3 in the second cycle, and so on.

With this scheme it will be seen that if rotation 1 follows rotation 3 in any cycle, it follows rotation 4 in the cycle commencing a year later. In the early years of the experiment, the rotations will be duplicated in each block, but after the completion of one full rotation the two plots for any one rotation will have differed in their previous cropping.

The three year ley will be grazed by sheep throughout the three years. The lucerne and the one year ley will be cut for hay. To avoid affecting the barley yields by undersowing and by the inclusion of ryegrass and clover in the straw of some plots but not others, the leys will be sown after the barley crop is harvested.

Manuring

Each main plot is divided into two sub-plots, one of which will receive dung at the rate of 15 tons per acre applied to the indicator crops of potatoes. The same sub-plots will receive dung throughout the experiment.

All plots will be liberally manured with inorganic fertilizers. The different rotations will receive the same amount of phosphate and potash, but not of nitrogen.

Rates of Application, cwt. per acre

Year of rotation		Sulphate of ammonia	Super-phosphate	Sulphate of potash
1	Potatoes	3	3	1½
	Ley	1	3	1½
	Lucerne	–	3	1½
2	Wheat	1	–	–
	Ley	–	–	–
	Lucerne	–	–	–
3	One year ley	1	–	–
	Kale	3	–	–
	Ley	–	–	–
	Lucerne	–	–	–
4	Potatoes	3	3	1½
5	Barley	1	–	–

Preliminary years

Special arrangements are made for the preliminary years in blocks 5, 4, 2 and 1, and these are shown in the table on p. 137. As far as possible the normal sequence of cropping is followed in the preliminary years. The potato crops on block 4 in 1938, on block 2 in 1939 and on block 1 in 1940, receive the same application of dung applied to sub-plots, as the indicator potato crops in the normal rotation.

Varieties

Lucerne—Provence.
Wheat—Red Standard.
Potatoes—Majestic.
Barley—Plumage Archer.
Kale—Thousand Head.

Grass Ley—
- 14 lbs. Perennial Ryegrass per acre.
- 8 lbs. Cocksfoot per acre.
- 4 lbs. Late Flowering Red Clover per acre.
- 2 lbs. Wild White Clover per acre.

LEY EXPERIMENT, STACKYARD, WOBURN.

Sequence of cropping

P = Potatoes, B = Barley, W = Wheat, K = Kale, H = one year ley for hay, L = Ley
A = Lucerne (alfalfa)

Block	3	5	4	2	1
Sub-plot Nos.	No dung 43 34 45 40 41 37 47 36 * Dung 44 33 46 39 42 38 48 35	No dung 65 79 68 74 78 69 71 76 * Dung 66 80 67 73 77 70 72 75	No dung 58 60 53 64 55 61 50 51 * Dung 57 59 54 63 56 62 49 52	No dung 31 29 17 19 23 26 22 27 * Dung 32 30 18 20 24 25 21 28	No dung 14 3 2 6 7 12 9 15 * Dung 13 4 1 5 8 11 10 16
1938	L A P P L A P P	Barley	Potatoes	Barley	Barley
1939	L A W W L A W W	L A P P L A P P	Barley	Potatoes	H K H K K H K H
1940	L A H K L A H K	L A W W L A W W	L A P P L A P P	Barley	Potatoes
1941	Potatoes	L A H K L A H K	L A W W L A W W	L A P P L A P P	Barley
1942	Barley	Potatoes	L A H K L A H K	L A W W L A W W	L A P P L A P P
1943	L A P P P P L A	Barley	Potatoes	L A H K L A H K	L A W W L A W W
1944	L A W W W W L A	L A P P P P A L	Barley	Potatoes	L A H K L A H K
1945	L A H K H K L A	L A W W W W A L	L A P P P P L A	Barley	Potatoes
1946	Potatoes	L A H K K H A L	L A W W W W L A	L A P P P P A L	Barley
1947	Barley	Potatoes	L A H K H K L A	L A W W W W A L	L A P P P P L A
1948	L A P P A L P P	Barley	Potatoes	L A H K K H A L	L A W W W W L A
1949	L A W W A L W W	L A P P A L P P	Barley	Potatoes	L A H K H K L A
1950	L A H K A L K H	L A W W A L W W	L A P P A L P P	Barley	Potatoes
1951	Potatoes	L A H K A L K H	L A W W A L W W	L A P P A L P P	Barley
1952	Barley	Potatoes	L A H K A L K H	L A W W A L W W	L A P P A L P P
1953	L A P P P P A L	Barley	Potatoes	L A H K A L K H	L A W W A L W W
1954	L A W W W W A L	L A P P P P L A	Barley	Potatoes	L A H K A L K H
1955	L A H K K H A L	L A W W W W L A	L A P P P P A L	Barley	Potatoes
1956	Potatoes	L A H K H K L A	L A W W W W A L	L A P P P P L A	Barley
1957	Barley	Potatoes	L A H K K H A L	L A W W W W L A	L A P P P P A L
1958	L A P P L A P P	Barley	Potatoes	L A H K H K L A	L A W W W W A L
1959	L A W W L A W W	L A P P L A P P	Barley	Potatoes	L A H K K H A L
1960	L A H K L A H K	L A W W L A W W	L A P P L A P P	Barley	Potatoes

* The second line of subplots receive dung when the whole block carries potatoes.

The above arrangement of blocks and subplots is given to facilitate the understanding of the sequence and the progress of the experiment. The blocks are given in the order 3, 5, 4, 2, 1, since the rotations begin on block 3 in 1938 and on blocks 5, 4, 2 and 1 in 1939 to 1942 respectively. The plots (or pairs of subplots) appearing in the first four columns of each block carry the continuous rotations 1, 2, 3, 4 in this order. The plots appearing in the last four columns carry the sequences of rotations.

PLAN AND YIELDS, 1938

Yields in lb. per plot : Barley : grain left, straw right. Potatoes : total produce left, percentage ware right. Lucerne : green weight

Block											
I	1	26.4 * 25.5	3	36.0 36.0	2	3	29.0 33.7	2	31.6 * 34.8	4	Barley
	5	31.7 * 32.0	4	39.0 38.0	6	7	43.0 44.0	1	47.3 * 50.0	8	
	9	38.8 39.0	3	47.5 * 43.0	10	11	41.8 * 45.0	2	46.5 45.0	12	
	13	34.5 * 37.0	1	38.0 39.0	14	15	47.5 51.0	4	26.0 * 42.0	16	
II	17	38.8 39.0	3	38.3 * 36.0	18	19	36.7 41.0	4	34.2 * 42.0	20	Barley
	21	44.5 * 41.0	3	44.7 41.0	22	23	36.0 41.0	1	27.3 * 38.0	24	
	25	41.0 * 42.0	2	42.2 47.0	26	27	31.7 41.0	4	17.2 * 32.0	28	
	29	27.7 38.5	2	25.5 * 32.3	30	31	25.2 34.8	1	13.3 * 33.5	32	
III	33	212 *	2A	212	34	35	1062 * 91.1	4P	1178 92.4	36	Potatoes (P) Ley (L) Lucerne (A)
	37	203	2A	241 *	38	39	1028 * 92.9	4P	1188 92.8	40	
	41		1L	*	42	43		1L	*	44	
	45	1136 89.7	3P	1150 * 91.9	46	47	1213 92.4	3P	1268 * 94.7	48	
IV	49	1372 *	3	1076	50	51	961	4	1315 *	52	Potatoes
	53	1106	3	1426 *	54	55	1078	1	1312 *	56	
	57	1510 *	1	1114	58	59	1471 *	2	1043	60	
	61	962	2	1374 *	62	63	1395 *	4	903	64	
V	65	26.2 43.0	1	31.2 * 45.0	66	67	24.5 * 46.0	3	22.0 47.0	68	Barley
	69	25.7 37.0	2	38.5 * 54.0	70	71	36.2 56.0	3	26.5 * 44.0	72	
	73	33.7 * 60.0	4	50.2 71.0	74	75	40.8 * 59.0	4	32.8 61.0	76	
	77	44.7 * 64.0	1	54.0 77.0	78	79	40.2 72.0	2	26.2 * 74.0	80	

Area of each Sub-plot : 0.0390 acre.

* These sub-plots receive dung when the whole block carries potatoes (block IV in 1938).
1, 2, 3, 4 refer to the rotations, see p. 135.
The centre pathway serves as a road for bringing on sheep when the ley plots are to be grazed.

BLOCK I. Ploughed : Sept. 11, 20, March 7 and 8. Harrowed and barley drilled : March 9. Manures applied : March 10. Cut : Aug. 25 and 27. Variety : Plumage Archer.

BLOCK II. Ploughed : Sept. 11, 20 and March 8. Harrowed and barley drilled : March 9. Manures applied : March 10. Cut : Aug. 27. Variety : Plumage Archer.

BLOCK III. Ploughed : Sept. 11, 20, March 17 and 18. Harrowed : April 21 and 22. Rolled and bouted up for potatoes : April 22. Artificials applied and potatoes planted : April 23. Ley and lucerne plots rolled and harrowed : May 19. Seeds sown, harrowed, rolled and lucerne sown : May 20. Manures applied on ley and lucerne plots : May 21. Potato plots hoed : June 22. Lucerne plots hoed : July 1-5. Potato plots rebouted : July 7. Seeds plots grazed by sheep : Aug. 2-9 and Sept. 6-14. Lucerne cut : Sept. 14. Potatoes lifted : Sept. 22-28. Varieties : Potatoes : Majestic. Lucerne : Garton's Provence.

BLOCK IV. Ploughed : Sept. 11-20. Dung applied : March 14. Ploughed and harrowed : March 31. Rolled and bouted up for potatoes : April 21. Artificials applied and potatoes planted : April 22. Hoed and bouts broken down : June 22. Bouts built up : July 5. Potatoes lifted : Sept. 30, Nov. 16 and 18. Variety : Majestic.

BLOCK V. Ploughed : Sept. 11, 20 and March 7. Harrowed, rolled and barley drilled : March 9. Manures applied : March 10. Rolled : May 20. Cut : Aug. 25. Variety : Plumage Archer.

SPECIAL NOTE. Potatoes in Block III passed over a 1⅝ inch riddle to determine percentage ware.

WHEAT

Effects of fallow and of one-year leys of clover, ryegrass and clover and ryegrass, cut once and followed by summer fallow or by green manure crops of mustard or vetches, or cut twice. Effects of sulphate of ammonia applied to leys and to wheat.

RW—FOSTERS, 1938

W ↑

C1 (L) C V N (R) R2 (L) C M N (L) F2 N (R) R1 (R) C R2 N (R) R V N (R) C2 (L) F1 N (R) C R1 N (R) R M N (R) C R V (R) C R M (R) F M (L) F V (L)	C M (R) C1 N (R) F V N (L) R1 N (R) R V (L) R2 N (R) C V (R) C R9 (R) F2 (L) C R1 (R) R M (L) C R M N (R) C R V N (L) C2 N (R) F1 (R) F M N (L)
F1 (L) F M N (R) R V N (L) C2 N (L) F V (L) R M (L) F2 N (R) R2 (L) C1 (R) C R M (L) C R1 N (R) C R V N (R) C M N (R) C V (L) C R2 (L) R1 N (L)	C R 2 N (L) C M (L) C2 (R) F2 (L) R2 N (L) C R V (R) F1 N (L) C R1 (L) F M (R) R V (L) R M N (L) F V N (L) C V N (R) C1 N (L) C R M N (R) R1 (L)

Note.—The plots were split for sulphate of ammonia applied to the wheat as a top dressing. (L) the left half of the plot received this dressing and (R) the right half received the dressing.

SYSTEM OF REPLICATION : 4 randomized blocks of 16 plots each, the plots being split for sulphate of ammonia at the rate of 0.3 cwt. N per acre applied as a top dressing to the wheat.

AREA OF EACH SUB-PLOT : 1/80 acre (68.7 lks. × 18.2 lks.).

TREATMENTS : 4 × 4 × 2 ×2 factorial design.

Fallow (F), clover (C), clover and ryegrass mixture (CR), ryegrass (R).

Vetches sown after first cut (V), mustard sown after first cut (M), summer fallow after first cut (1), two cuts taken (2).

Sulphate of ammonia : None, 0.3 cwt. N per acre applied to the leys (N).

Sulphate of ammonia applied as top dressing to wheat : None, 0.3 cwt. N per acre (see note below plan).

BASAL MANURING : Nil.

CULTIVATIONS, ETC. : 1936. Leys sown under barley.

Ploughed : March 16 and 17. Harrowed : March 31 and May 7. Rolled : May 4 and 7. Barley sown : March 31. Variety : Plumage Archer. Seeds sown : May 5 and 6. Varieties : Montgomery Red Clover and Italian Ryegrass. Barley harvested : August 31.

1937-8.

Ploughed fallow plots : Jan. 4-7. Applied sulphate of ammonia to ley plots : April 13. Rolled ley plots : April 26. Harrowed fallow plots : April 28. Cultivated fallow plots : June 10. Cut ley plots : June 15. Ploughed all plots except second cut leys : June 29-July 2. Harrowed July 6, 8, 9, 12 and 13. Rolled : July 6, 9, 12, 13 and 14. Vetches sown : July 12. Mustard sown : July 13. Thistles cut on all plots excepting second cut plots : August 6. Cut second crop : Sept. 2. Ploughed all plots : Sept. 15-28. Harrowed : Oct. 21, Nov. 3 and March 17. Rolled : Oct. 21 and March 21. Wheat sown : Nov. 3. Variety : Victor. Applied top dressing of sulphate of ammonia : March 15. Hand hoed : May 12. Harvested : August 12 and 13.

SPECIAL NOTE : Barley 1936 ; the yield of grain was estimated from the weight of the total produce per plot by means of random sampling from the stooks to determine the grain-straw ratio. The samples suffered from attacks by mice before threshing. Standard error per plot : Grain : 3.85 cwt. per acre or 15.3%.

STANDARD ERRORS : Grain : per plot : 1.81 cwt. per acre or 5.94% ; per sub-plot : 1.96 cwt. per acre or 6.31%.

Barley, 1936

Grain : cwt. per acre (±0.962)

		Ley undersown		
None	Clover	Clover and Ryegrass	Ryegrass	*Mean*
24.8	26.6	23.7	25.2	*25.1*

Effect of Nitrogen on Leys, 1937

Dry Matter : cwt. per acre

Nitrogen to leys	Clover	Clover and Ryegrass	Ryegrass
	First Cut		
None	30.1	44.6	27.6
0.3 cwt. N per acre	30.7	48.4	42.0
Increase	*+0.6*	*+3.8*	*+14.4*
	Second Cut		
Mean	*18.1*	*13.6*	*4.2*

Green manure crops : Nitrogen buried lb. per acre

	Fallow	Clover	Clover and Ryegrass	Ryegrass	*Mean*
Mustard	101.4	70.9	31.9	14.0	*54.5*
Vetches	110.6	57.4	31.9	48.6	*62.1*

Effects of Leys and nitrogen applied to wheat

Nitrogen to wheat	Fallow	Clover	Clover and Ryegrass	Ryegrass	*Mean*	Standard Errors
	Grain : cwt. per acre (±0.640*, ±0.490†)					
None	35.8	33.8	27.7	24.9	*30.5*	
0.3 cwt. N per acre ..	36.8	33.5	28.7	27.4	*31.6*	
Mean	*36.3*	*33.6*	*28.2*	*26.2*	*31.0*	*±0.453*
Increase		*−2.7*	*−8.1*	*−10.1*		
Difference	*+1.0*	*−0.3*	*+1.0*	*+2.5*	*+1.1*	*±0.693*
Increase		*−1.3*	*0.0*	*+1.5*		
	Straw : cwt. per acre					
None	40.4	38.2	30.1	25.8	*33.6*	
0.3 cwt. N per acre ..	42.2	39.2	32.5	29.8	*35.9*	
Mean	*41.3*	*38.7*	*31.3*	*27.8*	*34.8*	
Increase		*−2.6*	*−10.0*	*−13.5*		
Difference	*+1.8*	*+1.0*	*+2.4*	*+4.0*	*+2.3*	
Increase		*−0.8*	*+0.6*	*+2.2*		

* For comparisons involving the averages of the two levels of sulphate of ammonia.
† For comparisons involving the differences of the two levels of sulphate of ammonia.

Effect of green manures and of nitrogen to leys

	Nitrogen to Leys cwt. N per acre	1 cut	2 cuts	Mustard	Vetches
	GRAIN : cwt. per acre (±1.28, *Means: ±0.905*)				
Fallow	0	36.1[1]		34.6	36.4
	0.3	37.8[1]		34.6	37.2
	Mean	*37.0*[2]		*34.6*	*36.8*
Clover	0	36.0	30.8	32.0	34.8
	0.3	34.4	33.0	35.3	32.4
	Mean	*35.2*	*31.9*	*33.6*	*33.6*
Clover and Ryegrass ..	0	29.4	31.2	26.5	26.0
	0.3	28.9	27.6	26.9	29.0
	Mean	*29.2*	*29.4*	*26.7*	*27.5*
Ryegrass	0	29.6	21.8	22.3	27.8
	0.3	33.6	22.0	23.6	27.9
	Mean	*31.6*	*21.9*	*23.0*	*27.8*
	STRAW : cwt. per acre				
Fallow	0	41.3		37.4	41.2
	0.3	44.2		37.4	43.7
	Mean	*42.8*		*37.4*	*42.4*
Clover	0	41.6	35.0	35.6	40.9
	0.3	41.5	37.0	38.8	39.4
	Mean	*41.6*	*36.0*	*37.2*	*40.2*
Clover and Ryegrass ..	0	32.6	34.1	28.8	30.0
	0.3	32.1	29.0	29.7	34.0
	Mean	*32.4*	*31.6*	*29.2*	*32.0*
Ryegrass	0	32.2	21.8	22.6	31.0
	0.3	37.6	21.8	25.4	30.4
	Mean	*34.9*	*21.8*	*24.0*	*30.7*

Standard Errors : (1) ±0.905, (2) ±0.640.

Conclusions

There were no significant effects of the leys sown under barley on the yields of barley grain.

Sulphate of ammonia applied to the leys had no appreciable effect on the yields of clover, but increased the dry matter in the first cut of the clover-ryegrass mixture by 3.8 cwt. per acre and the dry matter in the first cut of ryegrass by 14.4 cwt. per acre.

The amount of nitrogen in the green manure crops ploughed under was greatest after fallow and considerably greater after clover than after the other leys.

All three leys produced significant reductions as compared with fallow in the yield of wheat grain, the average reduction being 2.7 cwt. per acre after clover, 8.1 cwt. per acre after clover-ryegrass mixture and 10.1 cwt. per acre after ryegrass. For clover and for ryegrass, the decreases in yield were significantly greater with two cuts of the ley than with a single cut followed by a summer fallow, but for the clover-ryegrass mixture the decreases were about the same.

The growing of a green manure crop of mustard or vetches also reduced the yield of wheat grain significantly as compared with a summer fallow. The average reduction was 3.7 cwt. per acre with mustard and 1.8 cwt. per acre with vetches, the difference between the two green manures being significant.

The residual effects of the nitrogen applied to the leys were not significant. Sulphate of ammonia applied to the wheat produced a significant increase of 1.1 cwt. per acre. The increases did not differ significantly according to the previous treatment, but it may be noted that there was no increase after clover.

CLOVER

Second year residual effect of dung, straw and sulphate of ammonia applied to the potato crop of 1936

RC—Great Harpenden, 1938

Plan and yields of hay in lb.

1	St N 97	DL 108	St 106	DL St 81	DE 96	DE St 80	DE N 64	DL St 83	8
W	N 88	DE St N 110	DL St N 116	DE 91	Nil 69	DL 82	St 57	DE St N 63	
↑	Nil 91	DL N 111	DE St 118	DE N 95	DL N 74	St N 68	DL St N 76	N 37	
	Nil 80	DE St N 102	St 104	N 76	DE 74	St N 54	St 59	DE N 78	
	St N 74	DE N 107	DL St N 110	DL St 81	DL St N 67	DL 58	DL St 59	DL N 74	
41	DE St 108	DE 100	DL 108	DL N 88	DE St 86	DE St N 55	N 42	Nil 64	48

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

AREA OF EACH PLOT : 1/40 acre (45.5 lks. x 54.9 lks.).

TREATMENTS : Applied to potatoes in 1936 (see 1936 Report, p. 213) : 3 x 2 x 2 factorial design.

Dung : None, 15 tons per acre ploughed in in December (DE), or an equivalent amount stored and applied in the bouts (DL).

Straw : None, 40 cwt. per acre (chaffed) (St), ploughed in in December, except when applied with DL, for which straw and dung were mixed and stored.

Sulphate of ammonia : None, 0.4 cwt. N per acre applied in the bouts (N).

BASAL MANURING : 0.5 cwt. P_2O_5 per acre as superphosphate, and 1 cwt. K_2O per acre as sulphate of potash applied in the bouts (applied in 1936) ; 0.2 cwt. N as sulphate of ammonia (applied in 1937).

CULTIVATIONS, ETC. : Clover undersown in oats and harrowed in : May 19, 1937. Variety : Montgomery Red. Previous crops : Oats (see 1937 Report, p. 153), and Potatoes (see 1936 Report, p. 213).

STANDARD ERROR PER PLOT : 3.62 cwt. per acre or 12.2%.

Summary of Results : Yields of separate treatments

HAY : cwt. per acre (±1.81)

		No dung	Dung	
			Ploughed in	In the bouts
No sulph. amm.	No straw	27.1	32.2	31.8
	Straw	29.1	35.0	27.1
Sulph. amm.	No straw	21.7	30.7	31.0
	Straw	26.2	29.5	33.0
Mean		*26.0*	*31.8*	*30.7*

Conclusions

Dung applied to potatoes in 1936 resulted in a significant increase in the yield of clover hay of 5.3 cwt. per acre. There were no other significant effects.

SPRING OATS

Residual effect of dung, straw, sulphate of ammonia, superphosphate and sulphate of potash applied to preceding potato crop

RO—Gt. Knott, 1938

Plan and yields in lb., grain above, straw below

1	DEN$_1$P 83.8 67.2	DESt 97.4 62.6	N$_2$St 94.1 60.9	N$_2$StP 85.3 55.7	Nil 80.5 57.5	DEN$_2$StK 100.6 69.4	6
	P 83.4 60.6	StK 83.0 57.0	DEN$_2$ 99.2 65.8	StPK 81.8 53.2	DLN$_1$StP 95.4 68.6	DLN$_2$ 99.5 62.5	
	N$_1$ 81·2 50.8	DLN$_2$StK 102.3 62.7	DEN$_1$StK 97.1 63.9	DEN$_1$ 92.9 61.1	N$_1$StK 79.6 54.4	DLP 90.6 62.4	
	DL 80.8 61.2	DLStPK 95.7 73.3	N$_2$PK 95.7 62.3	N$_2$K 89.4 72.6	DEStP 99.9 64.1	N$_1$P 92.2 62.8	
	DLN$_1$St 91.3 72.7	DEPK 86.4 63.6	DLN$_1$PK 94.3 71.7	DEN$_2$P 106.6 74.4	DLStK 103.0 74.0	DLN$_2$StPK 105.8 71.2	
NW ↑	DLN$_2$P 80.0 83.0	N$_1$StPK 89.1 65.9	DEN$_2$StPK 94.0 68.0	DEN$_1$StPK 92.3 68.7	DEK 96.4 70.6	DLN$_1$K 103.7 63.3	
	DEN$_1$K 95.4 74.6	N$_1$St 96.9 64.1	DLPK 102.3 68.7	DEN$_2$K 105.6 78.4	St 91.2 61.8	DEP 101.0 69.0	
	N$_2$StPK 100.4 66.6	DLN$_2$StP 104.6 76.4	DLN$_1$ 101.4 67.6	DLStP 95.0 65.0	DEN$_2$StP 111.9 79.1	DEStK 101.0 69.0	
	DLN$_1$StPK 90.9 66.1	N$_1$PK 93.3 62.7	K 89.5 55.5	DEN$_1$St 98.0 67.0	N$_1$StP 95.4 63.6	DLN$_2$St 99.1 64.9	
	DE 86.9 58.1	StP 73.7 48.3	DEN$_2$St 95.8 65.2	DEN$_1$PK 99.6 73.4	DLN$_1$P 110.2 65.8	N$_2$StK 92.2 62.8	
	DEN$_2$PK 101.6 71.4	DEN$_1$StP 94.2 68.8	DEStPK 96.0 63.0	DLN$_2$PK 103.8 71.2	DLN$_1$StK 106.3 65.7	PK 87.7 58.3	
67	DLN$_2$K 86.8 56.2	DLSt 80.4 51.6	N$_2$ 83.3 51.7	DLK 91.2 56.8	N$_1$K 82.9 49.1	N$_2$P 83.1 46.9	72

System of Replication: 4 randomized blocks of 18 plots each. Certain interactions confounded with block differences.

Area of each plot: 1/40 acre.

Treatments: Applied to potatoes in 1937 (see 1937 Report, p. 155) : 3 × 3 × 2^3 factorial design.

Dung: None, 15 tons per acre ploughed in in January (DE), or an equivalent amount stored and applied in the bouts (DL).

Straw: None, 40 cwt. per acre (chaffed) (St), ploughed in in January, except when applied with DL, for which straw and dung were mixed and stored.

Sulphate of ammonia: None, 0.4 (N_1), 0.8 (N_2) cwt. N per acre.

Superphosphate: None, 0.8 cwt. P_2O_5 per acre (P).

Sulphate of potash: None, 1.6 cwt. K_2O per acre (K).

Basal Manuring: None in 1937. Sulphate of ammonia: 1 cwt. per acre in 1938.

Cultivations, etc.: Ploughed during January. Cultivated: Feb. 5. Seed sown: March 1. Sulphate of ammonia applied: March 4. Harrowed: March 1, 11. Rolled: Marrch 14. Clover under-sown: June 7. Covered in with horse rake. Harvested: Aug. 3. Variety: Marvellous. Previous crop: Potatoes.

Special Note: Three random samples per plot were taken from the sheaves to determine the grain-straw ratio.

Standard Error per Plot: Grain: 2.33 cwt. per acre or 6.94%.

Summary of residual effects of nitrogenous fertilizers

Sulph. amm. (cwt. N)	No straw			Straw		
	No Dung	Dung Ploughed in	Dung In the bouts	No Dung	Dung Ploughed in	Dung In the bouts
	GRAIN : cwt. per acre (±1.16)					
0.0	30.5	33.1	32.6	29.4	35.2	33.4
0.4	31.2	33.2	36.6	32.2	34.1	34.3
0.8	31.4	36.9	33.0	33.2	35.9	36.8
	STRAW : cwt. per acre					
0.0	20.7	23.3	22.2	19.7	23.1	23.6
0.4	20.1	24.7	24.0	22.1	24.0	24.4
0.8	20.8	25.9	24.4	22.0	25.2	24.6

Main effects : Interactions of Dung

Dung	Sulph. amm. (cwt. N)			Straw (cwt.)		Super. (cwt. P_2O_5)		Sulph. pot. (cwt. K_2O)		*Mean*	*Increase*
	0.0	0.4	0.8	0	40	0.0	0.8	0.0	1.6		
	GRAIN : cwt. per acre										
None ..	29.9[1]	31.7	32.3	31.0[2]	31.6	31.1[2]	31.6	31.0[2]	31.7	*31.3*	
Ploughed in	34.2	33.6	36.4	34.4	35.1	34.7	34.7	34.8	34.7	*34.7*	*+3.4*[2]
In the bouts	33.0	35.4	34.9	34.1	34.8	34.1	34.8	33.6	35.3	*34.4*	*+3.1*[2]
Mean ..	*32.4*	*33.6*	*34.5*	*33.2*	*33.8*	*33.3*	*33.7*	*33.1*	*33.9*	*33.5*	
Increase ..		*+1.2*[2]	*+0.9*[2]		*+0.6*[3]		*+0.4*[3]		*+0.8*[3]		
	STRAW : cwt. per acre										
None ..	20.2	21.2	21.4	20.6	21.3	20.7	21.0	20.3	21.4	*20.9*	
Ploughed in	23.2	24.3	25.5	24.6	24.0	24.0	24.8	23.8	24.8	*24.3*	*+3.4*
In the bouts	22.9	24.2	24.5	23.5	24.2	22.6	25.1	23.8	23.8	23.8	*+2.9*
Mean ..	*22.1*	*23.2*	*23.8*	*22.9*	*23.2*	*22.4*	*23.6*	*22.6*	*23.3*	*23.0*	
Increase ..		*+1.1*	*+0.6*		*+0.3*		*+1.2*		*+0.7*		

St. errors : (1) ±0.824, (2) ±0.673, (3) ±0.549.

Interactions of Sulphate of ammonia with Straw and Minerals

Sulph. amm. (cwt. N)	Straw (cwt.)		Super. (cwt. P_2O_5)		Sulph. pot. (cwt. K_2O)	
	0	40	0.0	0.8	0.0	1.6
	GRAIN : cwt. per acre (±0.673)					
0.0	32.0	32.7	32.2	32.5	31.6	33.2
0.4	33.7	33.5	33.5	33.7	33.7	33.5
0.8	33.8	35.3	34.2	34.9	34.0	35.1
	STRAW cwt. per acre					
0.0	22.1	22.1	21.9	22.3	21.5	22.7
0.4	22.9	23.5	22.4	24.0	23.2	23.2
0.8	23.7	23.9	23.0	24.6	23.4	24.2

Conclusions

The residual effect of dung was significant, with an increase in yield of just over 3 cwt. per acre of grain, there being no difference due to the manner in which the dung was applied in the previous year.

The residual effect of the double dressing of sulphate of ammonia produced a significant increase of 2.1 cwt. of grain per acre. The residual effects of the minerals and straw were small and not significant.

SUGAR BEET

Effect of agricultural salt, superphosphate and muriate of potash, ploughed in in January, broadcast in February, broadcast in March, broadcast at sowing, and of dung

RS—Pastures, 1938

Plan and yields in lb.

Roots (dirty), tops, sugar percentage and plant number in descending order

1	Na DM$_1$ 584 805 16.44 572	Na PM$_2$ 526 658 16.07 557	KP M$_3$ 512 820 16.04 545	Na PM$_4$ 564 887 15.61 494	PM$_2$ 483 726 15.66 508	D M$_3$ 446 671 15.58 532	D M$_1$ 452 672 15.69 510	Na KPM$_1$ 418 645 15.61 526	8
	K P M$_1$ 476 670 16.30 605	NaKPDM$_1$ 589 723 16.24 563	Na DM$_3$ 603 835 15.75 559	M$_1$ 452 747 14.82 537	P M$_4$ 448 728 15.61 553	KPDM$_1$ 514 676 15.61 572	Na KDM$_2$ 430 620 15.29 536	NaKPM$_3$ 474 696 15.64 544	
	Na KM$_2$ 529 581 16.07 627	KDM$_4$ 484 654 15.98 600	KDM$_2$ 560 898 15.92 598	PDM$_4$ 527 856 15.43 589	Na M$_1$ 466 704 15.00 550	NaPDM$_2$ 570 688 16.44 598	NaKDM$_4$ 486 682 15.32 562	KPDM$_3$ 448 678 15.00 599	
W ↑	NaKPDM$_3$ 603 674 16.27 617	PDM$_2$ 476 680 15.46 602	NaKM$_4$ 603 749 16.01 579	M$_3$ 488 713 15.58 576	NaM$_3$ 516 799 15.87 569	NaPDM$_4$ 524 728 15.43 580	KM$_2$ 389 604 14.92 541	K M$_4$ 378 559 15.29 598	
	Na KM$_3$ 556 623 16.76 596	Na DM$_2$ 547 720 16.07 601	KDM$_1$ 552 758 15.66 619	M$_4$ 446 720 15.55 592	Na M$_4$ 532 772 15.49 572	Na KDM$_3$ 516 694 16.04 569	NaKDM$_1$ 492 664 16.04 528	NAKPM$_2$ 320 694 16.44 568	
	NaKPDM$_2$ 598 734 15.55 612	KPM$_4$ 458 638 15.87 604	Na PM$_1$ 550 664 15.75 603	P DM$_3$ 516 744 15.12 578	Na PDM$_1$ 542 765 15.95 563	PM$_1$ 360 565 15.61 461	P M$_3$ 390 636 14.71 490	KPDM$_4$ 434 700 15.61 592	
	KDM$_3$ 500 729 15.69 591	M$_2$ 351 558 15.00 555	Na DM$_4$ 570 749 15.72 594	KPM$_2$ 493 730 15.32 584	DM$_4$ 532 756 14.89 524	KPDM$_2$ 454 686 15.00 528	Na PDM$_3$ 434 706 14.54 501	Na M$_2$ 466 678 15.66 564	
57	Na PM$_3$ 552 626 15.90 610	PDM$_1$ 467 644 15.61 597	Na KPDM$_4$ 592 768 15.46 566	Na KM$_1$ 538 752 15.06 538	D M$_2$ 528 798 15.29 483	Na KPM$_4$ 402 528 15.55 405	K M$_3$ 332 562 15.52 369	K M$_1$ 340 575 15.00 490	64

System of Replication : 4 randomized blocks of 16 plots each. Certain interactions partially confounded with block differences.

Area of each Plot (after rejecting edge-rows) : 1/48 acre. Plots actually 1/40 acre (82.5 lks. x 30.3 lks.).

Treatments : 4 x 2^4 factorial design.

Dung : None, 10 tons per acre ploughed in at end of January (D).
Agricultural salt : None, 5 cwt. per acre (Na).
Superphosphate : None, 0.5 cwt. P_2O_5 cwt. per acre (P).
Muriate of potash : None, 1.0 cwt. K_2O per acre (K).
Minerals ploughed in in January (M_1), broadcast in February (M_2), broadcast in March (M_3), broadcast at sowing (M_4).

Basal Manuring : 0.6 cwt. N per acre as sulphate of ammonia.

Cultivations, etc. : Minerals (M_1) applied : Nov. 29. Dung applied : Nov. 30. Ploughed : Jan. 25-Feb. 3. Minerals (M_2) applied : Feb. 3. Cultivated : March 8, 11. Harrowed : March 12, May 11, 12. Rolled : March 12, May 11, 12. Minerals (M_3) applied : March 21. Minerals (M_4) and basal dressing applied : May 10. Seed sown : May 12. Horse hoed : June 14, July 12-15. Singled : June 29-July 5. Hand hoed : July 25-Aug. 22 on various dates. Lifted : Dec. 5-10. Variety : Kleinwanzleben E. Previous crop : wheat.

Special Note : The minerals (M_1) were applied on November 29, but owing to bad weather conditions they were not ploughed in till the end of January instead of shortly after applying as was intended.

Standard Errors per Plot : Total sugar : 2.63 cwt. per acre or 9.50%. Tops : 1.51 tons per acre or 10.1%. Mean dirt tare : 0.157.

Effects of mineral manures

	Minerals								
	None	Salt	Mur. of pot.	Salt and Mur. of pot.	Super.	Salt and super.	Mur. of pot. and super.	All	*Mean*
TOTAL SUGAR : cwt. per acre (±1.86)									
M_1	24.9^1	29.9	24.9	28.5	23.4	32.1	29.4	29.0	*28.2^2*
M_2		29.9	26.0	27.9	26.6	32.6	25.1	25.3	*27.6^2*
M_3		32.9	24.1	32.6	25.2	27.2	26.7	31.7	*28.6^2*
M_4		31.4	23.6	31.1	27.6	29.4	25.1	27.9	*28.0^2*
ROOTS (washed) : tons per acre									
M_1	8.14	9.46	8.07	9.18	7.49	10.09	9.22	9.09	*8.94*
M_2		9.39	8.38	8.87	8.52	10.04	8.27	7.97	*8.78*
M_3		10.36	7.71	9.94	8.43	8.91	8.59	9.90	*9.12*
M_4		10.06	7.50	9.92	8.89	9.46	7.98	8.99	*8.97*
TOPS : tons per acre (±1.07									
M_1	15.09^3	16.17	14.28	15.17	12.95	15.31	14.42	14.66	*14.71^4*
M_2		14.98	16.09	12.87	15.06	14.42	15.17	15.30	*14.84^4*
M_3		17.51	13.83	14.11	14.79	14.27	16.05	14.68	*15.03^4*
M_4		16.30	13.00	15.33	16.97	17.30	14.34	13.89	*15.30^4*
SUGAR PERCENTAGE									
M_1	15.30	15.72	15.33	15.55	15.61	15.85	15.96	15.92	*15.71*
M_2		15.86	15.42	15.68	15.56	16.26	15.16	16.00	*15.70*
M_3		15.81	15.60	16.40	14.92	15.22	15.52	15.96	*15.63*
M_4		15.60	15.64	15.66	15.52	15.52	15.74	15.50	*15.60*
PLANT NUMBER : thousands per acre									
M_1	25.9	26.9	26.6	25.6	25.4	28.0	28.2	26.1	*26.7*
M_2		28.0	27.3	27.9	26.6	27.7	26.7	28.3	*27.5*
M_3		27.1	23.0	28.0	25.6	26.7	27.5	27.9	*26.5*
M_4		28.0	28.8	27.4	27.4	25.8	28.7	23.3	*27.1*

Standard errors : (^{1}) ±0.930, (^{2}) ±0.703, (^{3}) ±0.534, (^{4}) ±0.404.

$_1$=Minerals ploughed in in January. M_2=broadcast in February.
M_3=broadcast in March. M_4=broadcast at sowing.

Differential responses to fertilizers

		Differential responses							
	Mean response	Dung		Salt		Muriate of potash		Superphosphate	
		Absent	Present	Absent	Present	Absent	Present	Absent	Present
TOTAL SUGAR : cwt. per acre (±0.930. *Means* : ±*0.658*)									
Dung	*+3.2*	—	—	+4.1	+2.3	+2.8	+3.6	+3.7	+2.6
Salt	*+4.5*	+5.4	+3.6	—	—	+5.4	+3.6	+5.7	+3.3
Muriate of potash	*−0.5*	−0.9	−0.2	+0.3	−1.4	—	—	−0.6	−0.4
Superphosphate . .	*+0.1*	+0.6	−0.4	+1.3	−1.1	0.0	+0.2	—	—
ROOTS (washed) : tons per acre									
Dung	*+1.01*	—	—	+1.30	+0.72	+0.87	+1.16	+1.10	+0.92
Salt	*+1.25*	+1.54	+0.96	—	—	+1.49	+1.02	+1.62	+0.88
Muriate of potash	*−0.26*	−0.40	−0.11	−0.02	−0.49	—	—	−0.28	−0.22
Superphosphate . .	*+0.03*	+0.12	−0.06	+0.40	−0.34	0.00	+0.06	—	—
TOPS : tons per acre (±0.534. *Means* : ±*0.378*)									
Dung	*+1.04*	—	—	+1.40	+0.67	+0.85	+1.22	+1.35	+0.72
Salt	*+0.31*	+0.68	−0.06	—	—	+0.77	−0.15	+0.61	+0.01
Muriate of potash	*−0.83*	−1.01	−0.64	−0.37	−1.28	—	—	−1.33	−0.32
Superphosphate . .	*−0.03*	+0.29	−0.34	+0.27	−0.32	−0.53	+0.48	—	—
SUGAR PERCENTAGE									
Dung	*+0.02*	—	—	+0.04	0.00	+0.10	−0.05	+0.24	−0.19
Salt	*+0.34*	+0.36	+0.32	—	—	+0.38	+0.29	+0.39	+0.28
Muriate of potash	*+0.15*	+0.22	+0.08	+0.19	+0.10	—	—	+0.14	+0.16
Superphosphate . .	*+0.04*	+0.26	−0.17	+0.10	−0.01	+0.03	+0.06	—	—
PLANT NUMBER : thousands per acre									
Dung	*+1.1*	—	—	+1.5	+0.6	+0.6	+1.6	+0.4	+1.8
Salt	*+0.4*	+0.9	0.0	—	—	+1.2	−0.3	+1.2	−0.3
Muriate of potash	*+0.3*	−0.2	+0.8	+1.1	−0.5	—	—	+0.2	+0.4
Superphosphate . .	*+0.1*	−0.6	+0.8	+0.9	−0.6	0.0	+0.3	—	—

Conclusions

Dung gave a significant increase of 3.2 cwt. per acre in sugar and 1.0 tons per acre in tops. Salt increased total sugar by 4.5 cwt. per acre, but its effect on tops was small and not significant.

The response in sugar to dung was somewhat greater in the absence of salt than in its presence. While this difference was not significant, a significant effect of the same type was observed at Woburn (see page 157).

Muriate of potash had no apparent effect on sugar and decreased the tops significantly by 0.8 tons per acre.

The effects of superphosphate were negligible.

No significant differences were produced by the different methods of applying the minerals.

KALE

Effect of sulphate of ammonia, poultry manure, soot, rape dust and dung

RK—Foster's, 1938 (5th year)

Plan and yields in lb.

1	D_4 465	N_2 494	M_2 520	O 414	O 388	D_4 532	D_2 441	N_1 526	8
SW ↑	S_2 438	D_2 409	N_1 457	O 364	O 340	D_2 444	M_2 500	N_2 567	
	O 347	D_2 461	R_2 538	O 330	R_2 547	S_2 511	O 321	O 350	
	O 362	N_2 542	O 389	D_4 513	D_4 554	R_2 550	D_2 448	D_2 476	
	O 333	M_2 495	O 370	D_2 415	O 330	N_2 548	N_1 461	S_2 465	
41	D_2 432	S_2 498	R_2 508	N_1 440	O 326	O 348	O 312	M_2 482	48

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

AREA OF EACH PLOT (after rejecting edge rows): 0.0231 acre. Plots actually: 0.0289 acre (14 yds. × 10 yds.).

TREATMENTS: None, sulphate of ammonia at 0.4 cwt. and 0.8 cwt. N per acre (N_1, N_2) poultry manure (M_2), soot(S_2), rape dust (R_2) all at 0.8 cwt. N per acre, and dung at 0.8 cwt. and 1.6 cwt. N per acre (D_2, D_4).

BASAL MANURING: Superphosphate and muriate of potash applied to every plot to give a total of 1.0 cwt. P_2O_5 and 1.0 cwt. K_2O per acre, including the P_2O_5 and K_2O in the organic fertilizers.

CULTIVATIONS, ETC.: Dung spread: Feb. 10. Ploughed: Feb. 10-12. Rolled and harrowed: May 12, 19, 26 and June 1. Applied organic fertilizers: May 23. Applied artificials (sulphate of ammonia at half rate): May 25. Seed sown: June 1. Variety: Thousand head. First sowing failed. Rolled and harrowed: July 5 and 7. Seed resown: July 7. Top dressing (second half of the sulphate of ammonia): Aug. 10. Horse hoed: Aug. 2. Previous crop: Kale. Cut: Dec. 14, Jan. 12, Feb. 1, 17 and 27.

STANDARD ERROR PER PLOT: 0.544 tons per acre or 6.36%.

Summary of results

	Nil	Sulphate of ammonia		Poultry manure	Soot	Rape dust	Dung	
cwt. N per acre ..		0.4	0.8	0.8	0.8	0.8	0.8	1.6
Kale: tons per acre	6.78^1	9.09^3	10.37^3	9.63^3	9.22^3	10.34^3	8.50^2	9.95^3

Standard errors: (1) ±0.136, (2) ±0.188, (3) ±0.272.

Conclusions

All dressings produced significant increases in yield. At the 0.8 cwt. N per acre level of dressing, rape dust and sulphate of ammonia gave yields which were significantly higher than soot or dung and also higher than poultry manure, though this latter difference did not quite reach significance. The double dressing of dung was not significantly different from the single dressings of the other four fertilizers.

At both levels of application, sulphate of ammonia was slightly though not significantly better than a double dressing of dung.

KALE

Effect of sulphate of ammonia, dung, treated town refuse, superphosphate and muriate of potash

RK—Foster's, 1938

Plan and yields in lb.

51	$H_0 M_2$ 383	$S_0 M_1$ 384	$H_2 M_1$ 541	$S_0 M_0$ 414	$D_0 M_2$ 420	$D_1 M_0$ 460	$D_2 M_0$ 503	$H_2 M_2$ 586	$D_0 M_1$ 508	75
	$S_2 M_0$ 510	$D_0 M_0$ 370	$H_1 M_0$ 521	$H_1 M_2$ 433	$H_0 M_1$ 398	$H_2 M_0$ 501	$S_1 M_0$ 497	$D_1 M_2$ 498	$S_0 M_2$ 466	
49	$S_1 M_2$ 446	$D_1 M_1$ 422	$D_2 M_2$ 466	$S_1 M_1$ 469	$D_2 M_1$ 467	$S_2 M_2$ 545	$H_1 M_1$ 496	$H_0 M_0$ 399	$S_2 M_1$ 574	73

SYSTEM OF REPLICATION : 3 randomized blocks of 9 plots each.

AREA OF EACH PLOT (after rejecting edge rows) : 0.0202 acre. Plots actually : 1/40 acre (60.6 lks. × 41.3 lks.).

TREATMENTS : 3 × 3 × 3 factorial design.

Nitrogenous fertilizers : None ($_0$), single dressing ($_1$), double dressing ($_2$) of sulphate of ammonia (S), treated town refuse* (H), dung (D). The single dressing was 0.4 cwt. N per acre for sulphate of ammonia and 0.8 cwt. for treated town refuse and dung.

Minerals : None (M_0), single dressing (M_1), double dressing (M_2), the single dressing being 0.4 cwt. P_2O_5 and 0.5 cwt. K_2O per acre.

BASAL MANURING : Nil.

CULTIVATIONS, ETC. : Applied dung and town refuse : April 2. Ploughed : April 4-6. Rolled and harrowed : May 12, 19, 26, 31. Applied artificials : May 25. Seed sown : May 31. Horse hoed : June 30, July 8, 19. Cut : Dec. 15-Feb. 10. Variety : Thousand head. Previous crop : Barley.

SPECIAL NOTE : *Town refuse screened, and fermented in silos.

STANDARD ERROR PER PLOT : 0.698 tons per acre or 6.71%.

Main effects and interactions of amount of nitrogen with kind of nitrogenous manure and minerals

Amount of nitrogen	Sulphate of ammonia	Treated town refuse	Dung	Minerals None	Minerals Single dressing	Minerals Double dressing	*Mean*	*Increase*
			KALE : tons per acre (±0.403)					
None		9.20[1]		8.73	9.52	9.36	*9.20*[1]	
Single dressing ..	10.42	10.70	10.18	10.91	10.24	10.16	*10.43*[1]	*+1.23*[2]
Double dressing ..	12.02	12.01	10.60	11.77	11.67	11.79	*11.54*[1]	*+1.11*[2]
Mean	*11.22*[3]	*11.36*[3]	*10.39*[3]	*10.27*[1]	*10.48*[1]	*10.44*[1]	*10.39*	
Increase		*+0.14*[4]	*−0.83*[4]		*+0.21*[2]	*−0.04*[2]		

Standard errors : (1) ±0.233, (2) ±0.329, (3) ±0.285, (4) ±0.403.

Interaction of kind of nitrogenous manure with minerals (adjusted for block differences)

	Minerals None	Minerals Single dressing	Minerals Double dressing
KALE :	tons per acre (±0.451)		
Sulphate of ammonia ..	11.08	11.13	11.43
Treated town refuse ..	11.78	11.43	10.88
Dung	10.24	10.30	10.62

Conclusions

It should be noted that sulphate of ammonia was applied at half rate per unit of N as compared with town refuse and dung.

All three nitrogenous fertilizers produced significant increases in the yield of kale. There was little difference between the responses to sulphate of ammonia and treated town refuse, but the response to the double dressing of dung was significantly less than the response to the double dressings of the other two fertilizers.

Minerals produced no significant results.

POTATOES

Effect of fresh and stored dung, superphosphate, sulphate of potash, straw and of sulphate ammonia

RP—Pastures, 1938

Total produce in lb. on left and percentage ware on right

1	**DrPK** 202 N_0 81.3 247 N_1 88.1 277 N_2 87.8	**Dr** 192 N_0 83.3 218 N_1 84.0 234 N_2 85.0	**P** 72 N_1 49.6 95 N_2 58.4 95 N_0 57.2	**DfStPK** 233 N_1 88.0 210 N_0 84.9 282 N_2 88.7	**StP** 77 N_0 45.5 120 N_1 64.3 132 N_2 66.1	**Dr** 182 N_0 82.9 208 N_2 84.7 221 N_1 86.1	121
	DrStP 255 N_0 86.8 292 N_2 88.8 258 N_1 86.6	**K** 202 N_1 84.3 158 N_0 81.6 211 N_2 84.1	**DfStP** 252 N_0 88.2 248 N_2 87.0 267 N_1 89.1	**DfSt** 259 N_2 88.7 207 N_0 87.6 236 N_1 86.7	NIL 106 N_0 61.9 90 N_1 55.5 229 N_2 83.7	**StK** 184 N_1 82.0 167 N_2 76.8 199 N_0 84.0	
	St 278 N_2 88.1 222 N_1 85.6 232 N_0 84.8	**DfPK** 304 N_1 90.1 267 N_0 89.2 320 N_2 88.9	**Df** 285 N_0 89.1 282 N_2 87.5 306 N_1 90.5	**DrPK** 314 N_1 88.2 265 N_0 85.6 324 N_2 88.2	**DrStP** 278 N_0 86.3 318 N_2 88.9 319 N_1 88.6	**DrStK** 289 N_2 86.6 230 N_0 84.5 265 N_1 85.8	
S ↑	**StPK** 284 N_0 87.5 327 N_2 89.3 301 N_1 88.5	**DrStK** 292 N_1 88.6 312 N_2 88.2 290 N_0 86.0	**DfStK** 298 N_1 88.6 279 N_0 88.0 276 N_2 87.8	**PK** 330 N_2 87.7 217 N_0 83.9 279 N_1 86.0	**DfK** 293 N_2 89.8 285 N_0 88.5 293 N_1 87.8	**DfP** 290 N_0 87.4 309 N_1 89.0 323 N_2 89.7	
	DrSt 337 N_2 90.6 289 N_1 89.7 230 N_0 87.8	**StK** 290 N_2 87.5 194 N_0 83.1 184 N_1 86.2	**DrP** 271 N_0 87.3 298 N_1 88.6 287 N_2 89.9	**DrK** 253 N_0 87.4 240 N_1 85.9 240 N_2 89.2	**DrP** 262 N_0 88.1 259 N_1 88.0 266 N_2 86.8	**DrSt** 308 N_1 89.1 219 N_0 86.7 251 N_2 88.0	
	DfK 255 N_1 88.9 234 N_0 86.4 288 N_2 88.1	**DrK** 198 N_0 84.4 243 N_1 86.0 299 N_2 89.9	**DfSt** 193 N_0 86.9 233 N_1 85.8 264 N_2 88.5	**DrStPK** 212 N_0 86.0 253 N_1 87.9 302 N_2 89.5	**DfPK** 216 N_0 87.5 310 N_2 90.0 266 N_1 88.1	**P** 132 N_2 69.7 127 N_0 73.3 170 N_1 80.9	
	StP 243 N_0 88.2 260 N_2 87.9 248 N_1 88.4	**DrStPK** 297 N_1 90.2 260 N_0 90.0 310 N_2 90.1	NIL 189 N_0 84.7 232 N_2 86.6 203 N_1 82.4	**StPK** 215 N_0 87.1 273 N_1 88.8 284 N_2 89.8	**K** 162 N_0 83.4 185 N_1 84.0 215 N_2 83.7	**DfStP** 217 N_1 88.5 226 N_0 87.3 273 N_2 89.9	
24	**DfP** 293 N_1 90.9 300 N_0 89.4 346 N_2 91.4	**DfStPK** 295 N_0 91.4 327 N_2 89.6 337 N_1 91.7	**PK** 217 N_0 83.5 262 N_1 85.6 298 N_2 88.9	**Df** 269 N_1 89.0 234 N_0 88.3 277 N_2 89.6	**DfStK** 279 N_1 89.4 284 N_2 90.1 232 N_0 88.2	**St** 221 N_2 84.7 141 N_0 77.4 151 N_1 78.0	144

SYSTEM OF REPLICATION : 4 randomized blocks of 12 plots each, the plots being split for sulphate of ammonia at the rates of 0, 0.4 and 0.8 cwt. N per acre.

AREA OF EACH SUB-PLOT (after rejecting edge bouts) : 0.00882 acre. Plots actually 0.01176 acre (42 lks. × 28 lks.)

TREATMENTS : $3^2 \times 2^3$ factorial design.

Dung : None, 15 tons fresh (Df), 15 tons stored (Dr) per acre.
Straw : Dung made with normal amount of straw, or with 50% additional straw (St).
Superphosphate : None, 0.8 cwt. P_2O_5 per acre (P).
Sulphate of potash : None, 1.6 cwt. K_2O per acre (K).
Sulphate of ammonia : None, 0.4 cwt., 0.8 cwt. N per acre (N_0, N_1, N_2).

BASAL MANURING : Nil.

CULTIVATIONS, ETC. : Feb. 10-16, ploughed. March 16, rolled and harrowed. April 17, rolled and ridged. April 21-23, applied artificials and stored dung. April 25-26, applied fresh dung. April 27-29, potatoes planted. May 19, rolled. June 3, ridged. June 4, harrowed. June 21, hand hoed. June 24-July 1, grubbed. July 7-27, hand hoed. July 20-21, earthed up. Oct. 17-20, lifted. Variety : Ally. Previous crop : Wheat.

Special Notes : Potatoes passed through a 1 $\frac{3}{4}$ inch riddle to determine percentage ware.

There was a marked drop in fertility from the centre of the site towards the south end. The whole-plot yields of total produce were corrected for this fertility gradient by estimating the relative fertilities of the top four rows in the plan by the method of least squares. The standard error per whole plot was reduced by these corrections from 12.8 per cent. to 8.2 per cent.

Standard Errors : Total produce : per whole plot : 1.02 tons per acre or 8.21% ; per sub-plot: 1.11 tons per acre or 8.92%. Percentage ware : per whole plot : 16.3 ; per sub-plot : 3.38.

Mean yield
12.45 tons
Mean no dung
10.36 tons

Summary of effects of dung and artificial fertilizers

	Sulph. of Ammonia (cwt. N)	Superphosphate (cwt. P_2O_5) 0		Superphosphate (cwt. P_2O_5) 0.8		St. errors	Superphosphate (cwt. P_2O_5) 0		Superphosphate (cwt. P_2O_5) 0.8		St. errors
		Sulphate of potash (cwt. K_2O) 0	1.6	0	1.6		Sulphate of potash (cwt. K_2O) 0	1.6	0	1.6	
		TOTAL PRODUCE : tons per acre					PERCENTAGE WARE				
	0	8.18	9.27	8.38	10.83	±0.866*	77.2	83.0	66.0	85.5	±14.3*
No dung	0.4	8.15	9.80	9.24	13.14	±0.556†	75.4	84.1	70.8	87.2	±1.69†
	0.8	11.87	11.42	9.36	14.70		85.8	83.0	70.5	88.9	
	0	11.65	11.73	13.18	12.55	±0.626*	86.6	86.7	87.6	87.0	±10.0*
Dung ..	0.4	13.78	12.77	13.73	14.54	±0.393†	87.6	87.6	88.7	89.0	±1.20†
	0.8	13.99	13.50	14.57	15.94		87.8	88.7	89.0	89.1	

Comparison of fresh and stored dung

Dung	Straw Normal	Straw Additional	Superphosphate (cwt. P_2O_5) 0	0.8	Sulphate of potash (cwt. K_2O) 0	1.6	Sulphate of ammonia (cwt. N) 0	0.4	0.8	*Mean*
	TOTAL PRODUCE : tons per acre									
Fresh ..	13.55	13.35	12.75	14.15	13.16	13.75	12.36	13.56	14.44	*13.45*
Stored ..	13.59	13.48	13.06	14.02	13.81	13.27	12.20	13.85	14.56	*13.54*
St. errors	±0.361*						±0.278†			±*0.255**
	PERCENTAGE WARE									
Fresh ..	89.0	88.4	88.3	89.0	88.6	88.7	88.0	88.9	89.1	*88.7*
Stored ..	86.5	88.0	86.7	87.8	87.2	87.3	85.9	87.6	88.3	*87.3*
St. errors	±5.77*						±0.845†			±*4.08**

Comparison of normal and additional straw

Straw	Superphosphate (cwt. P_2O_5) 0	0.8	Sulphate of potash (cwt. K_2O) 0	1.6	Sulphate of ammonia (cwt. N) 0	0.4	0.8	*Mean*
	TOTAL PRODUCE : tons per acre							
Normal ..	13.03	14.11	13.84	13.30	12.48	13.74	14.50	*13.57*
Additional	12.77	14.06	13.12	13.71	12.08	13.67	14.50	*13.42*
St. errors	±0.361*				±0.278†			±*0.255**
	PERCENTAGE WARE							
Normal ..	87.2	88.3	87.8	87.7	86.6	88.1	88.5	*87.7*
Additional	87.8	88.5	88.0	88.3	87.3	88.4	88.8	*88.2*
St. errors	±5.77*				±0.845†			±*4.08**

* For comparisons involving means of the three levels of sulphate of ammonia.

† For comparisons involving differences between the three levels of sulphate of ammonia.

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Conclusions

The average response in total produce to dung was 3.1 tons per acre. The response was significantly greater in the absence of sulphate of potash than in its presence, and also slightly though not significantly greater in the absence of sulphate of ammonia than in its presence. There were no apparent differences between the effects of fresh and stored dung, or of normal and strawy dung.

The effects of dung on percentage ware were similar to those on yield; in particular, the increase to dung was 13.6 in the absence of potash and 2.7 in the presence of potash.

The double dressing of sulphate of ammonia produced a significant increase in total produce of 2.4 tons per acre. The response was significantly greater in the presence of potash than in its absence. The three-factor interaction between sulphate of ammonia, sulphate of potash and superphosphate was also statistically significant, the response to the double dressing of sulphate of ammonia being significantly greater on plots receiving neither or both the minerals than on plots receiving one of the minerals but not the other. No explanation of this effect can, however, be offered, and it is not supported by the results with the single dressing of sulphate of ammonia.

Sulphate of ammonia also produced a significant increase of 2.9 in percentage ware.

In addition to producing the effects noted above, sulphate of potash gave a significant average response of 0.8 tons per acre in total produce and superphosphate a significant average response of 1.2 tons per acre. The response to each was significantly greater in the presence of the other than in its absence.

Sulphate of potash gave a significant increase in percentage ware of 10.0 in the absence of dung, but had no appreciable effect in the presence of dung. Superphosphate had little effect on percentage ware.

SUGAR BEET

WOBURN

Effect of agricultural salt, muriate of potash and of superphosphate, ploughed in in December, or broadcast in January, broadcast in March, broadcast at sowing, and of dung

WS—Butt Close, 1938

Plan and yields in lb.

						Roots (dirty)	Tops	Sugar per cent.						Roots (dirty)	Tops	Sugar per cent.	
1	—	—	—	—	M_3	494	442	16.56	—	Na	—	K	M_3	530	513	16.50	33
	D	—	—	K	M_4	576	565	16.85	—	—	P	K	M_4	421	430	16.76	
	D	Na	—	—	M_1	570	594	16.67	D	—	—	K	M_1	556	619	16.07	
	D	Na	—	—	M_3	568	538	17.34	—	—	—	—	M_2	524	410	16.82	
	—	Na	—	K	M_2	518	450	16.79	—	Na	—	K	M_1	606	512	16.76	
	—	Na	P	—	M_4	525	449	16.64	—	—	P	K	M_2	508	399	16.79	
	D	—	P	—	M_2	538	535	16.82	D	—	—	K	M_3	548	533	16.82	
	—	Na	P	—	M_2	520	418	17.02	—	Na	P	—	M_1	520	402	16.93	
	—	—	P	K	M_3	518	467	16.85	D	—	P	—	M_3	550	609	16.01	
	D	—	—	K	M_2	571	500	16.79	D	Na	—	—	M_4	561	554	16.39	
	—	Na	—	K	M_4	469	459	16.62	D	Na	P	K	M_2	570	653	16.33	
	D	Na	P	K	M_3	537	539	17.31	D	—	P	—	M_1	554	527	16.56	
	D	—	P	—	M_4	566	533	17.19	D	Na	—	—	M_2	568	597	17.28	
W	—	—	P	K	M_1	474	421	16.79	—	Na	P	—	M_3	502	430	17.77	
↑	D	Na	P	K	M_1	523	570	16.70	—	—	—	—	M_4	431	392	16.24	
	—	—	—	—	M_1	418	380	17.04	D	Na	P	K	M_4	460	520	16.04	
	—	Na	—	—	M_1	507	556	16.68	—	Na	—	—	M_2	466	520	16.90	
	D	Na	—	K	M_4	572	567	16.36	—	Na	P	K	M_4	485	385	16.73	
	D	Na	P	—	M_2	512	599	16.07	D	—	—	—	M_4	502	527	16.87	
	—	—	P	—	M_4	438	457	15.90	D	Na	P	—	M_3	487	530	16.10	
	D	—	P	K	M_3	512	544	16.24	D	—	—	—	M_2	481	476	16.50	
	—	Na	P	K	M_1	491	439	15.92	—	Na	—	—	M_4	394	362	16.68	
	—	—	—	K	M_2	472	453	16.82	D	Na	P	—	M_1	459	507	16.42	
	D	—	P	K	M_1	525	552	16.33	D	—	P	K	M_2	466	496	16.73	
	—	—	—	K	M_4	498	479	16.59	—	—	P	—	M_1	427	385	16.33	
	—	Na	—	—	M_3	460	451	17.02	D	Na	—	K	M_1	438	461	16.50	
	D	Na	P	—	M_4	498	450	15.75	—	—	P	—	M_3	424	377	16.33	
	—	Na	P	K	M_3	486	464	16.39	—	Na	P	K	M_2	476	341	17.02	
	D	—	—	—	M_3	488	509	16.85	—	—	—	K	M_3	393	401	16.58	
	D	Na	—	K	M_2	531	577	16.88	D	Na	—	K	M_3	398	474	16.10	
	—	—	P	—	M_2	469	425	16.36	D	—	P	K	M_4	438	449	15.84	
32	D	—	—	—	M_1	518	534	16.53	—	—	—	K	M_1	391	367	17.05	64

System of Replication : 4 randomized blocks of 16 plots each. Certain interactions partially confounded with block differences.

Area of Each Plot (after rejecting two edge rows of each plot) : 1/60 acre. Plots actually 1/40 acre. (183.8 lks. × 13.6 lks.).

Treatments : 4 × 2^4 factorial design.

Dung : None, 10 tons per acre ploughed in, in December (D).
Agricultural salt : None, 5 cwt. per acre (Na).
Muriate of potash : None, 1 cwt. K_2O per acre (K).
Superphosphate : None, 0.5 cwt. P_2O_5 per acre (P).
Minerals ploughed in in December (M_1), broadcast in January (M_2), broadcast in March (M_3), broadcast at sowing (M_4).

Basal Manuring : Sulphate of ammonia at the rate of 0.6 cwt. N per acre.

Cultivations, etc. : Dung applied : Dec. 1. Minerals (M_1) applied : Dec. 1. Ploughed : Dec. 8. Minerals (M_2) applied : Jan. 3. Minerals (M_3) applied : March 29. Harrowed : April 13. Drilled and minerals (M_4) applied : April 13. Rolled : April 13. Harrowed : April 14. Sulphate of ammonia applied : April 14. Hand hoed : May 12-18. Singled : May 19-June 7 and June 15-30. Lifted : Oct. 17-31. Variety : Kleinwanzleben E. Previous crop : Barley.

Standard Errors per Plot : Total sugar : 3.15 cwt. per acre or 7.99%. Tops : 1.14 tons per acre or 8.73%. Mean dirt tare : 0.112.

Effects of mineral manures

	None	Minerals Salt	Mur. of pot.	Salt and mur. of pot.	Super.	Salt and super.	Mur. of pot. and super.	All	*Mean*
				TOTAL SUGAR: cwt. per acre (±2.23)					
M_1 ..	38.6[1]	42.5	37.3	41.0	38.5	39.3	39.5	40.0	*39.7[2]*
M_2 ..		42.1	41.9	42.4	39.5	40.7	38.4	41.8	*41.0[2]*
M_3 ..		42.9	37.6	36.1	36.2	38.2	41.4	41.9	*39.2[2]*
M_4 ..		37.8	43.0	39.7	39.1	39.2	33.2	37.2	*38.5[2]*
				ROOTS (washed): tons per acre					
M_1 ..	11.58	12.72	11.32	12.31	11.69	11.77	11.93	12.25	*12.00*
M_2 ..		12.31	12.48	12.59	11.88	12.28	11.44	12.55	*12.22*
M_3 ..		12.47	11.25	11.06	11.21	11.25	12.50	12.40	*11.73*
M_4 ..		11.46	12.86	12.04	11.75	12.08	10.17	11.36	*11.67*
				TOPS: tons per acre (±0.802)					
M_1 ..	12.29[3]	15.40	13.21	13.03	12.21	12.17	13.03	13.51	*13.22[4]*
M_2 ..		14.96	12.76	13.75	12.86	13.62	11.99	13.31	*13.32[4]*
M_3 ..		13.25	12.51	13.22	13.21	12.86	13.54	13.43	*13.14[4]*
M_4 ..		12.27	13.98	13.74	13.26	12.04	11.77	12.12	*12.74[4]*
				SUGAR PERCENTAGE					
M_1 ..	16.68	16.68	16.56	16.63	16.44	16.68	16.56	16.31	*16.55*
M_2 ..		17.09	16.80	16.84	16.59	16.54	16.76	16.68	*16.76*
M_3 ..		17.18	16.70	16.30	16.17	16.94	16.54	16.85	*16.67*
M_4 ..		16.54	16.72	16.49	16.54	16.20	16.30	16.38	*16.45*

Standard errors: (1) ±1.12, (2) ±0.843, (3) ±0.401, (4) ±0.303.

M_1=Minerals ploughed in in December. M_2=broadcast in January.

M_3=broadcast in March. M_4=broadcast at sowing.

Differential responses to fertilizers

	Mean response	Differential responses							
		Dung		Salt		Muriate of potash		Superphosphate	
		Absent	Present	Absent	Present	Absent	Present	Absent	Present
TOTAL SUGAR : cwt. per acre (±1.11. *Means* : ±*0.788*)									
Dung	*+3.0*	—	—	+5.4	+0.6	+3.9	+2.1	+4.2	+1.8
Salt	*+1.4*	+3.8	−1.0	—	—	+1.8	+1.0	+1.2	+1.6
Muriate of potash	*+0.1*	+1.0	−0.8	+0.6	−0.4	—	—	−0.1	+0.3
Superphosphate	*−1.0*	+0.3	−2.2	−1.1	−0.8	−1.2	−0.8	—	—
ROOTS (washed) : tons per acre									
Dung	*+1.00*	—	—	+1.65	+0.34	+1.25	+0.74	+1.28	+0.71
Salt	*+0.38*	+1.04	−0.27	—	—	+0.44	+0.33	+0.34	+0.42
Muriate of potash	*+0.08*	+0.34	−0.18	+0.13	+0.03	—	—	+0.08	+0.08
Superphosphate	*−0.17*	+0.12	−0.46	−0.21	−0.13	−0.17	−0.16	—	—
TOPS : tons per acre (±0.402. *Means* : ±*0.284*)									
Dung	*+2.85*	—	—	+3.05	+2.64	+2.95	+2.74	+2.48	+3.22
Salt	*+0.58*	+0.78	+0.37	—	—	+0.74	+0.42	+1.00	+0.15
Muriate of potash	*+0.10*	+0.20	0.00	+0.26	−0.06	—	—	+0.14	+0.06
Superphosphate	*−0.39*	−0.76	−0.02	+0.03	−0.82	−0.35	−0.44	—	—
SUGAR PERCENTAGE									
Dung	*−0.16*	—	—	−0.05	−0.26	−0.12	−0.20	−0.05	−0.26
Salt	*+0.06*	+0.16	−0.04	—	—	+0.17	−0.06	+0.03	+0.08
Muriate of postash	*−0.05*	−0.01	−0.09	+0.06	−0.16	—	—	−0.14	+0.04
Superphosphate	*−0.17*	−0.07	−0.28	−0.20	−0.14	−0.26	−0.08	—	—

Conclusions

Dung produced significant increases of 3.0 cwt. per acre in sugar and 2.85 tons per acre in tops. The response to dung was 5.4 cwt. per acre of sugar in the absence of salt and only 0.6 cwt. per acre in the presence of salt, there being a significant negative interaction.

Minerals gave no significant results in either sugar or tops, though the responses to salt almost reached significance in both cases. The times and methods of application of the minerals had no apparent effect.

SUGAR BEET

WOBURN

Effect of sulphate of ammonia, dung, treated town refuse, superphosphate and muriate of potash

WS—Butt Close, 1938

Plan and yields in lb.

Roots (dirty), tops, sugar percentage, plant number and percentage bolters in descending order

67	**H1M1** 252 174 17.83 353 7.4	**D1M0** 287 195 17.51 368 1.6	**S1M2** 263 200 17.97 352 1.7	**D2M0** 257 170 16.99 358 3.9	**S0M0** 222 133 17.60 368 4.1	**D1M2** 251 167 17.74 362 2.5	**D0M0** 208 118 17.28 361 2.2	**D2M2** 230 145 17.89 343 3.8	**H0M1** 215 122 18.18 368 1.9	91
W ↑	**H0M0** 237 154 17.60 380 4.2	**S0M1** 273 166 17.16 378 1.3	**D2M1** 277 199 18.03 357 5.6	**H1M0** 275 184 17.37 354 4.5	**H0M2** 227 143 17.08 365 4.4	**H2M1** 308 221 17.34 345 5.5	**D1M1** 257 161 17.80 354 3.1	**H1M2** 243 142 18.06 340 4.7	**H2M0** 244 184 17.22 324 6.2	
65	**H2M2** 310 243 17.54 353 6.8	**S2M0** 323 279 17.08 348 5.5	**D0M2** 252 166 17.83 370 3.0	**S1M1** 258 190 17.63 350 4.9	**D0M1** 233 157 17.97 355 2.5	**S2M2** 304 265 17.05 339 7.4	**S1M0** 270 197 18.03 357 2.2	**S2M1** 266 211 17.25 354 3.1	**S0M2** 210 132 17.28 345 2.6	89

System of Replication: 3 randomized blocks of 9 plots each.

Area of Each Plot (after rejecting edge-rows): 0.0101 acre. Plots actually 0.0108 acre.

Treatments: 3 × 3 × 3 factorial design.

Nitrogenous fertilisers: None (0), single dressing (1), double dressing (2), of sulphate of ammonia (S), treated town refuse *(H), dung (D).

The single dressing was 0.4 cwt. N per acre for sulphate of ammonia and 0.8 cwt. for treated town refuse and dung.

Minerals: None (M0), single dressing (M1), double dressing (M2), the single dressing being 0.4 cwt. P_2O_5 and 0.5 cwt. K_2O per acre.

Basal manuring: Nil.

Cultivations, etc.: Ploughed: December, 1937 and April 1. Town refuse and dung applied: April 1. Harrowed: April 13. Rolled: April 13. Drilled: April 13. Artificials applied: April 14. Hand-hoed: May 19. Singled: May 26-30 and June 30. Horse-hoed: June 20-30. Lifted: Nov. 2. Variety: Kleinwanzleben E. Previous crop: Barley.

Special Note: * Town refuse screened, and fermented in silos.

Standard Errors per Plot: Total sugar: 2.57 cwt. per acre or 7.45%. Tops: 0.597 tons per acre or 7.60%. Mean dirt tare: 0.133.

Main effects and interactions of amount of nitrogen with kind of nitrogenous manures and minerals

Amount of nitrogen	Sulph. of amm.	Treated town refuse	Dung	Minerals None	Minerals Single dressing	Minerals Double dressing	*Mean*	*Increase*
TOTAL SUGAR : cwt. per acre (±1.49)								
None		30.5^{1}		29.6	32.7	29.3	*30.5^{1}*	
Single dressing ..	36.8	35.3	36.3	38.7	34.8	35.0	*36.1^{1}*	*$+5.6^{2}$*
Double dressing ..	37.7	38.0	34.9	35.8	38.0	36.8	*36.9^{1}*	*$+0.8^{2}$*
Mean	*37.2^{3}*	*36.7^{3}*	*35.6^{3}*	*34.7^{1}*	*35.1^{1}*	*33.7^{1}*	*34.5*	
Increase		*-0.5^{4}*	*-1.6^{4}*		*$+0.4^{2}$*	*-1.4^{2}*		
Standard errors : (¹) ±0.857, (²) ±1.21, (³) ±1.06, (⁴) ±1.48.								
ROOTS (washed) : tons per acre								
None		8.69		8.46	9.21	8.40	*8.69*	
Single dressing ..	10.28	9.95	10.28	10.96	9.80	9.75	*10.17*	*+1.48*
Double dressing	11.00	10.94	9.90	10.47	10.83	10.55	*10.62*	*+0.45*
Mean	*10.64*	*10.44*	*10.09*	*9.96*	*9.95*	*9.58*	*9.83*	
Increase		*−0.20*	*−0.55*		*−0.01*	*−0.37*		
TOPS : tons per acre (±0.345)								
None		6.31^{5}		5.94	6.53	6.47	*6.31^{5}*	
Single dressing ..	8.61	7.33	7.67	8.45	7.70	7.47	*7.87^{5}*	*$+1.56^{6}$*
Double dressing ..	11.07	9.51	7.54	9.29	9.26	9.58	*9.37^{5}*	*$+1.50^{6}$*
Mean	*9.84^{7}*	*8.42^{7}*	*7.61^{7}*	*7.89^{5}*	*7.83^{5}*	*7.84^{5}*	*7.85*	
Increase		*-1.42^{8}*	*-2.23^{8}*		*-0.06^{6}*	*$+0.01^{6}$*		
Standard errors : (⁵) ±0.199, (⁶) ±0.281, (⁷) ±0.244, (⁸) ±0.345.								
SUGAR PERCENTAGE								
None		17.55		17.49	17.77	17.40	*17.55*	
Single dressing ..	17.88	17.75	17.68	17.64	17.75	17.92	*17.77*	*+0.22*
Double dressing ..	17.13	17.37	17.64	17.10	17.54	17.49	*17.38*	*−0.39*
Mean	*17.50*	*17.56*	*17.66*	*17.41*	*17.69*	*17.60*	*17.57*	
Increase		*+0.06*	*+0.16*		*+0.28*	*−0.09*		
PLANT NUMBER : thousands per acre								
None		36.0		36.4	36.2	35.5	*36.0*	
Single dressing ..	34.8	34.4	35.6	35.5	34.7	34.6	*34.9*	*−1.1*
Double dressing ..	34.2	33.6	34.8	33.8	34.7	34.0	*34.2*	*−0.7*
Mean	*34.5*	*34.0*	*35.2*	*35.2*	*35.2*	*34.7*	*35.0*	
Increase		*−0.5*	*+0.7*		*0.0*	*−0.5*		
PERCENTAGE OF BOLTERS (±0.852)								
None		2.91^{9}		3.50	1.90	3.33	*2.91^{9}*	
Single dressing ..	2.93	5.53	2.40	2.77	5.13	2.97	*3.62^{9}*	*$+0.71^{10}$*
Double dressing ..	5.33	6.17	4.43	5.20	4.73	6.00	*5.31^{9}*	*$+1.69^{10}$*
Mean	*4.13^{11}*	*5.85^{11}*	*3.42^{11}*	*3.82^{9}*	*3.92^{9}*	*4.10^{9}*	*3.95*	
Increase		*$+1.72^{12}$*	*-0.71^{12}*		*$+0.10^{10}$*	*$+0.18^{10}$*		
Standard errors : (⁹) ±0.492, (¹⁰) ±0.696, (¹¹) ±0.603, (¹²) ±0.853								

Interaction of kind of nitrogenous manures with minerals (adjusted for block differences)

		Minerals			Minerals	
	None	Single dressing	Double dressing	None	Single dressing	Double dressing
	TOTAL SUGAR : cwt. per acre (±1.66)			ROOTS (washed) : tons per acre		
Sulphate of Ammonia ..	39.6	36.0	36.2	11.26	10.32	10.32
Treated Town Refuse ..	36.2	37.4	36.4	10.46	10.64	10.24
Dung	35.8	35.7	35.1	10.41	9.98	9.88
	TOPS : tons per acre (±0.385)			SUGAR PERCENTAGE		
Sulphate of Ammonia ..	10.48	9.24	9.81	17.55	17.43	17.52
Treated Town Refuse ..	8.50	8.26	8.49	17.28	17.60	17.80
Dung	7.60	7.94	7.28	17.26	17.91	17.80
	PLANT NUMBER : thousands per acre			PERCENTAGE OF BOLTERS (±0.955)		
Sulphate of Ammonia ..	34.6	35.2	33.8	4.24	3.94	4.20
Treated Town Refuse ..	33.9	34.0	34.0	5.30	6.09	6.15
Dung	35.4	35.0	35.2	2.40	4.74	3.09

Conclusions

It should be noted that sulphate of ammonia was applied at half rate per unit of N as compared with town refuse and dung.

The nitrogenous fertilizers produced significant increases in total sugar and tops. For sulphate of ammonia and treated town refuse, the double dressing proved as effective as the single dressing per unit of N applied in tops, but somewhat less effective in sugar. For dung, there was no additional response to the double dressing either in sugar or tops.

The average responses in sugar to sulphate of ammonia and treated town refuse were about the same, the response to dung being lower, though not significantly so. The average response in tops to sulphate of ammonia was significantly greater than the responses to the other two fertilizers, and the response to town refuse was significantly greater than that to dung.

All three nitrogenous fertilizers produced significant increases in the percentage of bolters, the average increase being significantly greater with treated town refuse than with sulphate of ammonia or dung.

There were no significant effects of minerals.

KALE

WOBURN

The effects of roots and tops of mustard, tares and lupins used as green manures

WK—Lansome, 1937

Plan and yields in lb.

1	TAR	MR	LO	TA2TR	LR	MTR	F	LR	F	MR	10
	28	48	57	84	62	36	26	20	30	12	
I	M2TR	LTR	TATR	F	F	LO	M2TR	F	TAO	TAR	II
	38	84	78	42	45	17	33	16	10	10	
	TAO	L2TR	F	MO	MTR	MO	LTR	L2TR	TA2TR	TATR	
	44	105	69	51	51	28	90	73	59	28	
	LTR	TAO	LR	MO	F	LTR	TATR	F	F	TA2TR	
	55	14	46	37	37	68	60	44	35	30	
III	F	MTR	LO	F	TATR	LO	TAO	TAR	LR	MO	IV
	26	19	28	14	38	30	26	41	21	6	
	TA2TR	M2TR	MR	L2TR	TAR	M2TR	MR	MTR	F	L2TR	
51	19	14	15	62	12	37	17	24	14	44	60

SYSTEM OF REPLICATION : 4 randomized blocks of 15 plots each.
AREA OF EACH PLOT : 0.00478 acre.
TREATMENTS : Green manures : Fallow (F), tares (TA), lupins (L), mustard (M). Plants pulled up after growing (O), plants cut and removed, but roots left in ground (R), plants ploughed in as grown (TR), plants ploughed in and additional tops from (R) plots also buried (2TR).
DUNG was applied at the rate of 10 tons per acre to blocks I and IV.
BASAL MANURING : Nil.
CULTIVATIONS, ETC.: Ploughed : Feb. 3, 10 and 11. Harrowed, mustard, tares or lupins drilled : April 12. Applied dung : April 13. Tares redrilled : April 21. Mustard redrilled : May 6. Additional mustard and tares drilled : May 10. Green manure crop cut : July 8 and 9. Ploughed : July 10. Harrowed : July 12. Rolled and kale drilled : July 16. Hoed : Aug. 24-31. Singled and transplanted : Sept. 10-13. Kale harvested : Feb. 3 and 4. Variety : Thousand head. Previous crop : Kale.
STANDARD ERRORS PER PLOT : Area with no dung : 1.19 tons per acre or 41.3%. Area with dung : 1.37 tons per acre or 31.8%.

Nitrogen buried : lb. per acre

	No dung				Dung			
	Fallow*	R	TR	2TR	Fallow*	R	TR	2TR
Mustard		2	20	44		2	31	61
Lupins	9	18	156	295	18	16	162	289
Tares		6	43	104		7	61	117

* Nitrogen content of weeds on fallow plots.

Summary of Results : Kale : tons per acre

	Fallow	O	R	TR	2TR	*Mean*
			No Dung (±0.842)			
Mustard . .	2.34[1]	3.04	1.26	2.58	2.20	*2.27*[2]
Lupins . .		2.10	3.08	6.78	6.31	*4.57*[2]
Tares . .		1.12	1.02	3.08	3.65	*2.22*[2]
Mean (±*0.486*) . .	*2.34*	*2.09*	*1.79*	*4.15*	*4.05*	*2.88*
			Dung (±0.969)			
Mustard . .	3.88[3]	2.66	3.04	3.50	3.50	*3.18*[4]
Lupins . .		4.06	3.88	7.10	6.96	*5.50*[4]
Tares . .		3.27	3.22	6.45	5.32	*4.56*[4]
Mean (±*0.559*) . .	*3.88*	*3.33*	*3.38*	*5.68*	*5.26*	*4.31*

Standard errors : (1) ±0.486, (2) ±0.421, (3) ±0.559, (4) 0.484.

Conclusions

The yields of kale were very poor. Where whole plants or tops were removed, the growing of green manures produced a small though not significant decrease in yields. The burying of whole plants, with or without extra tops, gave significant increases over fallow of 3.7 tons per acre with lupins and 1.5 tons per acre with tares but no increase with mustard. There was, however, no extra response to the double dressing of tops with either lupins or tares.

Dung applied to whole blocks increased the yields by 1.4 tons per acre. There were no significant differences between the effects of the green manures on the dunged and undunged blocks.

KALE

WOBURN

The effects of roots and tops of mustard, tares and lupins used as green manures

WK—Butt Furlong, 1938

Plan and yields in lb.

1	TaR	MR	LO	Ta2TR	LR	MTR	F	LR	F	MR	10
	98	68	94	97	116	75	108	101	94	74	
	M2TR	LTR	TaTR	F	F	LO	M2TR	F	TaO	TaR	
	89	102	88	94	98	86	101	91	93	105	
	TaO	L2TR	F	MO	MTR	MO	LTR	L2TR	Ta2TR	TaTR	
	93	(82)	107	91	83	61	124	(100)	92	110	
	LTR	TaO	LR	MO	F	LTR	TaTR	F	F	Ta2TR	
	91	86	101	78	94	118	92	90	97	108	
	F	MTR	LO	F	TaTR	LO	TaO	TaR	LR	MO	
	94	76	89	94	90	104	107	101	94	78	
	Ta2TR	M2TR	MR	L2TR	TaR	M2TR	MR	MTR	F	L2TR	
51	91	86	64	(71)	84	91	78	86	98	(102)	60

SYSTEM OF REPLICATION : 4 randomized blocks of 15 plots each.

AREA OF EACH PLOT : 0.00478 acre.

TREATMENTS : Green manures : Fallow (F), tares (Ta), lupins (L), mustard (M). Plants pulled up after growing (O), plants cut and removed, but roots left in ground (R), plants ploughed in as grown (TR), plants ploughed in and additional tops from (R) plots also buried (2TR).

BASAL MANURING : Nil.

CULTIVATIONS, ETC.: Ploughed : March 23. Harrowed, rolled and lupins drilled : March 25. Vetches drilled : March 26. Tares, lupins and mustard drilled : May 3-5. Green crops cut : July 11. Ploughed : July 12 and 13. Harrowed, rolled and kale drilled : July 16. Hoed : July 29. Singled and kale transplanted : Aug. 10 and 11. Kale harvested : March 7, 11 and April 14, 1939. Variety : Thousand head. Previous crop : Sugar beet.

SPECIAL NOTES : The yields in brackets in the above plan were seriously affected by heavy snow in December. The tares crop was a failure ; the yields of kale are given above, although all the tares plots received the same treatment.

STANDARD ERROR PER PLOT : 0.756 tons per acre or 8.85%.

Nitrogen added : lb. per acre

	Fallow*	R	TR	2TR
Mustard . .	12	3	40	83
Lupins. . . .		11	104	186

* Nitrogen content of weeds on fallow plots.

Summary of Results : Kale : tons per acre (±0.378)

	Fallow	O	R	TR	2TR
Mustard . .	9.04^1	7.18	6.62	7.50	8.56
Lupins . .		8.68	9.64	10.17	†
Mean (±0.267)	*9.04^1*	*7.93*	*8.13*	*8.84*	*8.56^2*

Standard errors : (1) ±0.218, (2) ±0.378

† Yields affected by heavy snow.

Conclusions

The growing of a green manure crop of mustard, removing the tops or whole plant, significantly reduced the yields of kale as compared with fallow. Where tops were buried the yields of kale were increased, but even with the burying of the double dressing of tops the yields did not equal those after fallow. Lupins gave about the same yields of kale as fallow when tops were carted off, but a significant increase of 1.1. tons per acre over fallow when tops were buried.

KALE

WOBURN

Effect of sulphate of ammonia, poultry manure, soot, rape dust and dung

WK—Lansome, 1938 (5th year)

Plan and yields in lb.

1	D_4	N_2	D_2	N_1	D_2	D_2	O	S_2	8
	85	116	76	79	67	54	40	90	
	D_2	O	O	O	O	M_2	O	D_4	
NW	53	40	41	31	43	70	38	68	
↑	S_2	M_2	R_2	O	N_2	R_2	N_1	O	
	88	78	84	41	107	90	66	27	
	O	D_2	M_2	O	N_2	D_4	O	O	
	31	52	89	43	139	84	45	39	
	O	N_2	O	D_2	O	S_2	M_2	R_2	
	23	109	47	53	54	103	89	112	
	N_1	R_2	S_2	D_4	D_2	O	N_1	D_2	
41	61	90	96	91	82	50	97	81	48

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

AREA OF EACH PLOT (after rejecting edge rows): 1/192 acre. Plots actually 1/160 acre (25 lks. x 25 lks.).

TREATMENTS, 1938: None, sulphate of ammonia at 0.4 cwt. and 0.8 cwt. N per acre (N_1, N_2) half in seed bed and half as top dressing, poultry manure (M_2), soot (S_2), rape dust (R_2) all at 0.8 cwt. N per acre and applied in seed bed, and dung at 0.8 cwt. and 1.6 cwt. N per acre (D_2, D_4) ploughed in.

BASAL MANURING: Superphosphate and muriate of potash applied to every plot to give a total of 1.0 cwt. P_2O_5 and 1.0 cwt. K_2O per acre, including the P_2O_5 and K_2O in the organic fertilizers.

CULTIVATIONS, ETC.: Dung applied: Feb. 17. Ploughed: Feb. 21 and 22. Rolled and harrowed: June 7. Manures applied (sulphate of ammonia at half rate): June 7. Seed sown: June 7. Second half sulphate ammonia applied as top dressing: July 12. Cut: Dec. 6, Jan. 10, 12 and 13. Variety: Thousand head. Previous crop: Kale (see 1937 Report, p. 167).

STANDARD ERROR PER PLOT: 0.700 tons per acre or 11.8%.

Summary of results

cwt. N per acre	Nil	Sulphate of ammonia 0.4	 0.8	Poultry manure 0.8	Soot 0.8	Rape dust 0.8	Dung 0.8	 1.6
Kale: tons per acre	3.39[1]	6.49[3]	10.09[3]	6.99[3]	8.08[3]	8.06[3]	5.55[2]	7.03[3]

Standard errors: (1) ±0.175, (2) ±0.247, (3) ±0.350.

Conclusions

All dressings produced significant increases in yield. At the 0.8 cwt. N per acre level of dressing, sulphate of ammonia gave a significantly higher yield than any of the other manures; soot and rape dust gave significantly higher yields than poultry manure and poultry manure gave a significantly higher yield than dung.

At both levels of application, sulphate of ammonia proved significantly more effective than a dressing of dung containing twice the amount of N per acre.

LUCERNE

WOBURN

Influence of dung on effectiveness of inoculation

Stackyard, 1938

Plan and yields of hay in lb. per plot

1	OD_1 60.4	ID_1 56.8	ID_2 38.4	OD_0 56.1	ID_0 44.7	OD_2 35.6	6
	OD_0 70.8	ID_2 62.9	ID_0 45.6	OD_1 51.7	ID_2 39.9	OD_1 25.0	
	OD_2 64.7	ID_0 61.2	ID_1 57.4	OD_2 50.9	ID_1 24.1	OD_0 24.2	
	ID_1 76.3	OD_2 87.0	OD_0 71.3	ID_2 64.4	ID_1 40.9	OD_2 64.5	
	ID_0 65.6	OD_0 76.3	OD_1 74.4	ID_0 68.6	ID_2 72.9	OD_0 65.8	
31	ID_2 59.9	OD_1 67.4	OD_2 69.6	ID_1 61.9	ID_0 44.6	OD_1 55.5	36

System of Replication : 6 randomized blocks of 2 plots each, the plots being split for dung at the rates of 0, 5 and 20 tons per acre.

Area of each sub-plot : 1/100 acre.

Treatments : (applied in 1937). 3 × 2 factorial design.
Inoculated (I), not inoculated (O).
Dung : None, 5 tons, 20 tons per acre (D_0, D_1, D_2).

Basal Manuring : 10 cwt. lime per acre, applied Feb. 25, 1938.

Cultivations, etc. : 1937 : Ploughed : March 24 and April 22. Springtine harrowed : April 29, May 3 and 4. Rolled : May 3 and 4. Seed sown : May 4. Dung applied : May 4. Hoed : June 14-17, 20, 21 and July 7-20. Cut : Aug. 23. Variety : Provence. Previous crop : Wheat (1936).
1938 : Harrowed : Jan. 7 and Feb. 21. Lime applied : Feb. 25. Harrowed : March 2 and 28. 1st Cut : July 18. Harrowed : July 20. 2nd Cut : Sept. 15. Harrowed : Sept. 16 and 22. 3rd Cut : Nov. 24.

Special Note : A preliminary cut was taken in August, 1937, the average yield being 6 cwt. hay per acre.

Standard Errors : Per whole plot : 4.01 cwt. per acre or 8.02%. Per sub-plot : 7.62 cwt. per acre or 14.9%.

Summary of Results

HAY : cwt. per acre (±2.84*, ±3.11†).

	None	Dung 5 tons	20 tons	*Mean* (±*1.64**)	*Increase* (±*2.32**)
Not Inoculated	54.2	49.8	55.4	*53.1*	
Inoculated . .	49.2	47.2	50.4	*48.9*	*−4.2*
Mean (±*2.20†*)	*51.7*	*48.5*	*52.9*	*51.0*	
Increase (±*3.11†*)		*−3.2*	*+4.4*		

* For comparisons involving the mean of no dung and dung treatments.
† For comparisons involving the differences of no dung and dung treatments.

Conclusions

Inoculation resulted in a decrease of 4.2 cwt. of hay per acre though this amount was not quite significant. Dung produced no significant effects.

EXPERIMENTS ON POULTRY MANURE

Centres	Type of experiment	No. of plots	Year
Rothamsted (see p. 150 for details)	2aCR	48	5
Woburn (see p. 164 for details)	2aCR	48	5
Lady Manner's School, Bakewell	1C	16	5
St. Joseph's School, Castleford, Yorks	1C	16	3
Sailors' Orphan Homes School, Newland, Hull	1C	16	5
A. G. Brightman, Esq., Maulden, Beds. J. W. Dallas, Esq., County Organiser	3	24	4
Norton New Council School, Doncaster, Yorks	1C	16	3
Council School, Oxted, Surrey	1C	16	2
L. Pope, Esq., Pelton, Durham	1C	12	4
J. F. Broughton and Son, South Petherton, Somerset. University of Bristol, Agricultural Department	2CR	36	2
Church of England School, Staindrop, Darlington, Co. Durham	1C	16	5
Horticultural College, Swanley	2CR	24	1
County School, Welshpool, Montgomeryshire	1C	16	5
Central School, Withernsea, Yorks	1	16	1

Experimental arrangements

(1) 2^2 factorial design. P.M., S/A.
4 × 4 Latin squares or randomized blocks.
* Basal manuring : 1.0 cwt. K_2O and 0.8 cwt. P_2O_5 per acre.

(1C) Cumulative : As (1) with treatments applied on the same plots each year.

(2CR) Immediate, cumulative and residual effects. Manures S/A (S) and P.M. (M). Treatments as follows :

1st year	O	O	1S	1M	2S	2M
2nd year	2S	2M	1S	1M	O	O

Randomized blocks.
* Basal manuring : 1.0 cwt. K_2O and 1.0 cwt. P_2O_5 per acre.

(2aCR) As (2CR) with soot and rape dust, for the past four years. In the present year, the treatments were : O, half S/A, S/A, P.M., soot, rape dust, dung and double dung.

(3) Immediate, cumulative and residual effects. Treatments as follows :

1st year	O	O	M	M	O	O	S	S
2nd year	O	M	O	M	O	S	O	S
3rd year	M	M	O	O	S	S	O	O
4th year	M	O	M	O	S	O	S	O

Randomized blocks.
* Basal manuring : 1.0 cwt. K_2O and 0.8 cwt. P_2O_5 per acre.

* *Note.*—In all cases the mineral manures per plot were made up to 1.0 cwt. K_50 and 0.8 cwt. or 1.0 cwt. P_2O_5, using muriate of potash and superphosphate.

Rates of Manuring

(1), (1C) : N at the rate of 0, 0.6 and 1.2 cwt. per acre
(2CR) : N at the rate of 0, 0.4 and 0.8 cwt. per acre
(3) : N at the rate of 0, and 0.6 cwt. per acre.

Place	Crop	Area Acres	Soil	Variety	Manures applied	Seed sown	Harvested	Previous crop
Bakewell	Potatoes	1/102	Limestone	Gladstone	April 29	May 4-6	Sept. 28-Oct.31	Ryegrass
Castleford	Cabbages	1/166	Heavy loam	Ellams	April 6-13 June 30-July 6	April 6-13	Aug. 30-Sept. 30	Potatoes
Hull	Potatoes	1/161	Heavy alluvium	Catriona	May 6	May 6	Oct. 11	Cabbages
Maulden	Marrows	1/73	Sandy	Green Bush	April 28	May 21	Aug. 3-Oct. 12 (weekly)	Runner beans
Norton	Dwarf beans	1/237	Light loam	Canadian Wonder	May 2	May 9	July-Oct.	Cabbages
Oxted	Cabbages	1/161	Gault clay	Late Autumn	May 28	June 4	Oct.	Potatoes
Pelton	Potatoes	1/186	Medium loam	Arran Banner	April 8	April 7, 8	Sept. 7, 8	Swedes
South Petherton	Potatoes	1/110	Sandy loam	Sharpe's Express	March 22	March 23	June 30	Mangolds
Staindrop	Beetroot	1/160	Loam	Carter's Red Globe	May 18	May 20	Oct. 20	Potatoes
Swanley	Onions	1/152	Light calcareous	Unwin's Reliance	April 1	April 1-13	Sept. 19	Peas and spring cabbages
Welshpool	Potatoes	1/160	Medium loam	Arran Banner	May 5	May 8	Oct. 7	Potatoes
Withernsea	Swedes	1/290	Clay loam	Gartons	June 17	May 6	Oct. 18	Potatoes

Cumulative Experiments Types 1 and 1C

Year of experiment	Place	Crop	No. N	P.M.	S/A	S/A and P.M.	*Mean*	St. Error
First	Withernsea	Swedes : roots and tops : tons per acre	22.49	39.25	33.12	29.98	*31.21*	±0.855
Second	Oxted	Cabbages, total produce : tons per acre Cabbages, saleable %	12.20 77.0	14.05 82.0	16.82 81.3	14.66 78.8	*14.43* *79.8*	±0.910 ±5.20
Third	Castleford	Cabbages, total produce : tons per acre Cabbages, saleable %	21.50 94.2	18.69 95.0	19.43 92.5	19.82 95.4	*19.86* *94.3*	±0.562 ±0.834
	Norton	Dwarf beans : cwt. per acre	16.2	21.7	20.4	21.7	*20.0*	±0.252
Fourth	Pelton	Potatoes : tons per acre	10.85	11.10	14.48	13.62	*12.51*	±1.18
	Staindrop	Beetroot : tons per acre	8.53	8.98	9.42	6.80	*8.43*	±0.396
Fifth	Bakewell Hull Welshpool	Potatoes : tons per acre Potatoes : tons per acre Potatoes : tons per acre	4.80 6.56 8.11	6.11 7.74 9.96	8.09 6.49 11.29	6.97 7.65 9.80	*6.49* *7.11* *9.79*	±0.675 ±0.218 ±0.240

Conclusions

Poultry manure and sulphate of ammonia alone and in combination.

At Withernsea there were large responses to nitrogen in swedes total produce. The response to poultry manure was significantly greater than that to sulphate of ammonia, while the response to the combined dressing was significantly smaller than the responses to either of the individual dressings.

There was a significant response to nitrogen in cabbages at Oxted, the response to sulphate of ammonia being greater than that to poultry manure, though the difference did not reach significance. The increase to nitrogen in the percentage of saleable cabbages was not significant.

At Castleford, on the other hand, the dressings of nitrogen decreased the yields of cabbages significantly, there being no significant difference between the decreases to sulphate of ammonia and poultry manure. Nitrogen had no apparent effect on the percentage of saleable cabbages, which was high on all plots.

There was a substantial response to nitrogen in dwarf beans at Norton, poultry manure giving a significantly higher yield than sulphate of ammonia.

At Staindrop, both sulphate of ammonia and poultry manure gave small but not significant increases in the yield of beetroot, while the combined dressing produced a significant depression in yield of 1.7 tons per acre. A similar result was obtained when beetroot was grown on these plots in 1935.

All four experiments on potatoes showed significant increases to nitrogen. At Bakewell and Welshpool sulphate of ammonia gave a significantly higher yield than poultry manure, while at Pelton the difference in favour of sulphate of ammonia approached significance. At Hull, on the other hand, poultry manure gave a significant increase while there was no response to sulphate of ammonia applied alone.

Experiments on immediate, cumulative and residual effects

Type 2CR

Place	Year of experiment	Crop	1937 1938	2N ON	IN IN	ON 2N	*Mean*	St. error
Swanley	First	Onions: tons per acre (±0.950)	PM S/A	16.51[1]	16.20 16.80	18.08 15.11	*17.14* *15.96*	±0.672
			Mean (±0.672)	*16.51*	*16.50*	*16.60*	*16.54*	
		Percentage first grade (±4.63)	PM S/A	54.6[2]	48.0 50.1	61.2 51.0	*54.6* *50.6*	±3.27
			Mean (±3.27)	*54.6*	*49.0*	*56.1*	*53.2*	
South Petherton	Second	Potatoes: tons per acre (±0.133)	PM S/A	4.12 4.48	4.03 5.00	4.37 4.80	*4.17* *4.76*	±0.077
			Mean (±0.094)	*4.30*	*4.52*	*4.58*	*4.47*	
		Percentage Ware (±1.01)	PM S/A	87.8 88.9	87.9 86.6	87.9 89.2	*87.9* *88.2*	±0.583
			Mean (±0.714)	*88.4*	*87.2*	*88.6*	*88.0*	

Standard errors: (1) ±0.672, (2) ±3.27.

Conclusions

Immediate, cumulative and residual effects

The first-year experiments on onions at Swanley tests the immediate effects only of single and double dressings of poultry manure and sulphate of ammonia. There were no significant differences between treatments either in total produce or in the percentage of first grade onions.

There was a significant response to the direct application of nitrogen on potatoes at South Petherton, sulphate of ammonia giving significantly higher yields than poultry manure. The difference between the residual effects of sulphate of ammonia and poultry manure was not significant.

Experiments on immediate, cumulative and residual effects

Type 3

Place	Crop	1935 1936 1937 1938	N N O O	O N N O	N O O N	O O N N	*Mean*	St. error
Maulden ..	Marrows: tons per acre (±0.947)	PM S/A	14.06 13.97	14.76 14.26	16.34 12.84	13.64 15.66	*14.70* *14.18*	±0.474
		Mean (±0.670)	*14.02*	*14.51*	*14.59*	*14.65*	*14.44*	

Conclusions

The yields under the different treatments varied somewhat irregularly, but there were no significant differences.

SUGAR BEET FERTILISER EXPERIMENTS

Factory Series

System of Replication : 3 randomized blocks of 9 plots each with two degrees of freedom, representing second order interactions, confounded with block differences.

Area of each Plot : Wissington II and Oaklands I : 1/80 acre. Wissington I and Wissington III : 1/100 acre. Oaklands II : 1/110 acre. Remainder : 1/40 acre.

Treatments : 3×3×3 factorial design.
Sulphate of ammonia : None, 0.4 cwt., 0.8 cwt. N per acre.
Superphosphate : None, 0.5 cwt., 1.0 cwt. P_2O_5 per acre.
Muriate of potash : None, 0.6 cwt., 1.2 cwt. K_2O per acre.

Varieties : Schreiber S.K.W.E. : Colwick. Schreiber S.K.W. : King's Lynn II, Bardney I, Oaklands I, Newark I. Johnson's Perfection : Cupar I. Marsters : Kidderminster, Spalding I, Ely, Peterborough II. Sharpe's E. : Bury I. Kühn E. : Ipswich II. Remainder : Kleinwanzleben E.

Mechanical and chemical analyses of soil samples from each experiment have been carried out.

Station	Yield in tons per acre.	Plants in thousands per acre	Distance in inches between rows	Weight of roots in lb. per plant	Total sugar in lb. per plant	Increase in sugar for one additional plant
COARSE SANDS						
1 Allscott I	12.43	26.8	20	1.038	.176	+.104*
2 Allscott II	11.30	25.7	20	0.984	.162	−.017
3 Cantley I	4.15	26.1	16	0.356	.052	+.064**
4 Cantley II	6.00	41.4	19	0.325	.050	+.013
5 Colwick	6.31	25.0	20	0.566	.092	−.023
6 King's Lynn I	5.00	29.3	18	0.382	.059	+.002
7 King's Lynn II	5.95	26.6	19	0.500	.077	−.092**
8 Newark I	8.07	25.6	18	0.705	.123	+.031
9 Selby I	9.23	30.7	24	0.671	.110	+.033
10 Wissington I	12.75	24.2	15	1.176	.195	+.096*
11 Wissington III	8.19	36.8	22	0.499	.081	+.177*
FINE SANDS						
12 Bardney I	13.41	29.8	20	1.022	.170	—
13 Bardney II	9.23	29.9	18	0.692	.118	+.160**
14 Brigg I	14.24	25.2	18	1.263	.211	+.183*
15 Brigg II	10.57	25.5	18	0.926	.158	+.019
16 Bury II	5.06	17.4	21	0.650	.108	+.036
17 Cupar I	8.48	19.7	22	0.967	.157	−.163*
18 Ipswich I	6.08	24.5	19	0.555	.081	+.124*
19 Kidderminster	11.07	26.6	20	0.931	.157	+.092
20 Poppleton	6.59	22.7	22	0.648	.119	+.063
LIGHT LOAMS						
21 Bury I	—	—	22	—	—	—
22 Cupar II	8.59	29.8	20	0.644	.109	+.019
23 Ipswich II	6.79	28.6	18	0.530	.081	+.083*
24 Oaklands II	3.85	24.5	22	0.352	.050	+.013
25 Spalding I	4.07	25.1	22	0.363	.060	+.142**
HEAVY LOAM						
26 Peterboro' I	9.07	22.2	22	0.914	.153	+.115**
CLAY LOAMS						
27 Felstead	7.60	18.4	22	0.922	.147	+.016
28 Oaklands I	7.45	17.2	26	0.966	.161	+.074
29 Selby II	8.94	20.9	22	0.956	.146	+.078*
FENS						
30 Ely	14.62	32.4	20	1.011	.159	−.326**
31 Peterboro' II	6.26	30.0	20	0.466	.083	+.047
32 Wissington II	5.20	20.9	24	0.555	.072	+.164*

*=5% significance. **=1% significance

Note: At centres 1, 2, 6, 7, 9, 17, 18, 22, 23, 27 and 29, plant numbers were counted for only a fraction of the plot. For these centres the increases in sugar for one additional plant are not directly comparable with the yields of sugar per plant.

	Station	Soil	Previous crop	Date of sowing	Date of lifting	Farming notes
1	Allscott I	Sandy loam	Potatoes	April 5	Oct. 29	Dung and lime to beet
2	Allscott II	Sandy loam	Permanent pasture	May 20	Nov. 30	After old grass. Limed for beet
3	Cantley I	Mixed	Barley	April 7	Nov. 21 & 22	Suffered from drought
4	Cantley II	Sandy	Barley	Mid-April	Nov. 16	Suffered from drought
5	Colwick	Sand	Oats	April 12	Oct. 17	Very poor land
6	King's Lynn I	Sandy	Barley	May 16	Nov. 23	Suffered from drought
7	King's Lynn II	Sandy loam	Wheat	April 15	Oct. 26	Suffered from drought
8	Newark I	Moorland	Wheat	April 19	Nov. 4, 5 & 7	Factory "lime" for beet
9	Selby I	Light	Peas	April 15	Oct. 17, 18 & 19	—
10	Wissington I	Light loam	Barley	April 12	Nov. 18	Deep ploughed
11	Wissington III	Sand	Rye	April 13	Oct. 25	—
12	Bardney I	Sand	Wheat	April 14	Oct. 27	Dung for beet
13	Bardney II	Loam	Wheat	May 5*	Oct. 26	Redrilled
14	Brigg I	Sand	Oats	April 14	Nov. 1	Limed for beet
15	Brigg II	Medium loam	Barley	April 11	Nov. 28	—
16	Bury II	Light	Wheat	April 18	Nov. 8	Suffered from drought
17	Cupar I	Medium	Wheat	April 25	Oct. 24-26	Some game damage
18	Ipswich I	Sandy loam	Barley	April 28	Nov. 10 & 11	Suffered from drought
19	Kidderminster	Medium sand	Brussels Sprouts	April 23	Oct. 28-29	Very good land
20	Poppleton	Medium loam	Barley	April 28	Nov. 7	Limed for beet
21	Bury I	Light	Wheat	April 26	Nov. 17	—
22	Cupar II	Medium loam	Hay	April 25	Oct. 20	—
23	Ipswich II	Loam	Wheat	May 4	Nov. 21	Suffered from drought
24	Oaklands II	Gravel	Oats	April 13	Oct. 18	Suffered from drought
25	Spalding I	Medium gravel	Barley	April 19	Oct. 13 & 14	Suffered from drought
26	Peterboro' I	Heavy loam	Wheat	Mar. 28	Oct. 10	Dunged for beet
27	Felstead	Heavy clay	Fallow	April 20	Oct. 19	Suffered from drought
28	Oaklands I	Heavy loam	Oats	April 23	Nov. 15	—
29	Selby II	Strong warp	Wheat	April 12	Oct. 27	Limed for beet
30	Ely	Black fen	Potatoes	April 13	Nov. 25	Good land
31	Peterboro' II	Light black fen	Wheat	April 18	Nov. 17	—
32	Wissington II	Black fen	Wheat	April 13	Nov. 17	—

*Second sowing

Significant Responses

		N	P	K
Total sugar	(32)	+*	+*	+*
Tops	(28)	+*	0	0*
			Curvature	
Total sugar	..	−*	0	0
Tops ..	..	0	0	0
		N×P	N×K	P×K
Total sugar	..	0	0*	0
Tops ..	..	0	0*	0

Symbols

+ = Positive } Significant
0 = No } average
− = Negative } responses
(32) No. of centres
* = Significant differences between centres

Mean Responses per 1 cwt. of N, P_2O_5 and K_2O

	N		P		K	
	Average 1933-37	1938	Average 1933-37	1938	Average 1933-37	1938
Total sugar—cwt.	+4.8	+2.4	+1.4	+1.1	+1.3	+2.4
Roots—tons ..	+1.70	+0.95	+0.40	+0.39	+0.26	+0.59
Tops—tons ..	+3.47	+3.44	+0.42	+0.32	+0.14	+0.10
Sugar % ..	−0.55	−0.50	+0.02	−0.08	+0.22	+0.28
Plant number ..	+0.4	−0.2	+0.4	−0.1	+0.3	+0.3
Purity % ..	−0.5	−0.2	+0.3	−0.2	+0.1	+0.2

Main Effects and First Order Interactions

Total Sugar : cwt. per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		K_0	K_1	K_2
1	N_0	39.2	40.9	40.4	37.9	41.4	41.3	*40.2*	P_0	39.3	43.2	44.6
	N_1	45.8	45.1	43.5	44.1	45.0	45.4	*44.8*	P_1	42.3	43.2	42.6
	N_2	42.1	42.1	40.4	39.9	42.3	42.4	*41.5*	P_2	40.3	42.3	41.8
	Mean	*42.4*	*42.7*	*41.5*	*40.6*	*42.9*	*43.0*	*42.2*	±1.44. *Means : ±0.830*			
2	N_0	35.7	34.3	37.9	33.7	37.1	37.1	*36.0*	P_0	31.3	36.4	41.0
	N_1	38.0	39.5	40.9	37.7	39.0	41.8	*39.5*	P_1	35.4	36.3	39.4
	N_2	35.0	37.4	37.1	34.8	36.4	38.2	*36.5*	P_2	39.4	39.8	36.7
	Mean	*36.2*	*37.1*	*38.6*	*35.4*	*37.5*	*39.0*	*37.3*	±1.31. *Means: ±0.757*			
3	N_0	10.5	13.2	10.0	10.5	11.5	11.8	*11.3*	P_0	9.2	11.4	14.1
	N_1	11.6	13.0	13.3	9.9	11.9	16.1	*12.6*	P_1	10.4	12.5	14.2
	N_2	12.6	10.9	13.7	9.5	13.4	14.2	*12.4*	P_2	10.4	12.9	13.8
	Mean	*11.6*	*12.4*	*12.3*	*10.0*	*12.3*	*14.0*	*12.1*	±1.15. *Means: ±0.667*			
4	N_0	18.6	17.6	16.5	17.3	17.3	18.0	*17.6*	P_0	17.4	20.2	18.7
	N_1	19.1	18.4	18.4	16.7	19.2	19.9	*18.6*	P_1	17.7	18.7	20.2
	N_2	18.7	20.6	19.9	18.6	20.1	20.5	*19.7*	P_2	17.6	17.7	19.5
	Mean	*18.8*	*18.9*	*18.3*	*17.6*	*18.9*	*19.5*	*18.6*	±0.883. *Means: ±0.510*			
5	N_0	17.6	21.4	20.1	14.8	20.9	23.3	*19.7*	P_0	12.9	20.0	23.7
	N_1	19.3	23.8	22.3	16.3	23.4	25.7	*21.8*	P_1	16.4	23.5	25.5
	N_2	19.8	20.2	20.3	13.7	20.6	25.8	*20.1*	P_2	15.5	21.5	25.6
	Mean	*18.9*	*21.8*	*20.9*	*15.0*	*21.7*	*25.0*	*20.5*	±0.785. *Means: ±0.453*			
6	N_0	12.4	13.9	16.0	13.6	14.8	13.9	*14.1*	P_0	13.3	14.8	16.0
	N_1	16.4	15.4	16.2	14.3	16.0	17.7	*16.0*	P_1	14.6	16.2	16.3
	N_2	15.2	17.9	16.6	14.2	16.1	19.4	*16.6*	P_2	14.2	15.9	18.7
	Mean	*14.7*	*15.7*	*16.3*	*14.0*	*15.6*	*17.0*	*15.6*	±0.872. *Means: ±0.503*			
7	N_0	20.5	20.9	20.8	20.9	19.5	21.8	*20.7*	P_0	17.8	19.1	19.7
	N_1	20.3	16.5	17.0	16.9	18.2	18.7	*17.9*	P_1	18.8	18.3	17.3
	N_2	15.8	17.0	17.0	17.3	16.9	15.7	*16.6*	P_2	18.6	17.2	19.1
	Mean	*18.9*	*18.1*	*18.3*	*18.4*	*18.2*	*18.7*	*18.4*	±1.26. *Means: ±0.727*			
8	N_0	20.6	23.3	25.4	18.2	23.8	27.4	*23.1*	P_0	21.8	27.0	29.3
	N_1	27.7	31.1	33.1	23.7	31.0	37.2	*30.6*	P_1	21.9	29.7	34.9
	N_2	29.7	32.1	30.7	23.4	33.9	35.3	*30.8*	P_2	21.6	31.9	35.7
	Mean	*26.0*	*28.8*	*29.7*	*21.8*	*29.5*	*33.3*	*28.2*	±1.14. *Means: ±0.657*			
9	N_0	22.1	24.0	18.3	22.3	20.5	21.6	*21.5*	P_0	30.9	29.1	31.0
	N_1	32.2	34.1	32.9	35.6	32.5	31.1	*33.1*	P_1	33.2	32.2	30.2
	N_2	36.6	37.5	32.6	34.0	36.4	36.3	*35.6*	P_2	27.8	28.2	27.9
	Mean	*30.3*	*31.9*	*27.9*	*30.6*	*29.8*	*29.7*	*30.0*	±1.73. *Means: ±0.997*			
10	N_0	41.9	44.7	41.9	43.2	42.9	42.5	*42.8*	P_0	38.6	43.4	43.4
	N_1	43.3	43.2	41.8	38.9	44.1	45.4	*42.8*	P_1	41.8	42.3	43.1
	N_2	40.2	39.3	43.3	39.2	40.9	42.8	*40.9*	P_2	40.9	42.1	44.0
	Mean	*41.8*	*42.4*	*42.3*	*40.4*	*42.6*	*43.5*	*42.2*	±1.92. *Means: ±1.11*			
11	N_0	20.8	26.2	27.2	22.9	26.1	25.2	*24.7*	P_0	24.4	28.0	25.2
	N_1	29.0	25.9	23.6	26.1	25.8	26.6	*26.2*	P_1	22.5	27.9	31.8
	N_2	27.8	30.2	28.1	25.0	31.7	29.3	*28.7*	P_2	27.0	27.7	24.2
	Mean	*25.9*	*27.4*	*26.3*	*24.6*	*27.9*	*27.1*	*26.5*	±2.63. *Means: ±1.52*			

Total Sugar : cwt. per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		K_0	K_1	K_2
12	N_0	41.6	44.4	45.6	44.4	41.5	45.7	*43.9*	P_0	43.2	43.9	43.7
	N_1	45.3	44.5	44.5	42.8	45.1	46.4	*44.8*	P_1	42.6	43.4	47.6
	N_2	43.8	44.7	47.1	42.8	45.6	47.2	*45.2*	P_2	44.1	44.9	48.1
	Mean	*43.6*	*44.5*	*45.7*	*43.3*	*44.1*	*46.4*	*44.6*	±1.39. *Means* : ±*0.800*			
13	N_0	29.7	30.5	22.4	30.6	24.9	27.0	*27.5*	P_0	32.5	30.6	27.4
	N_1	30.6	31.8	34.4	32.4	30.1	34.4	*32.3*	P_1	33.2	32.8	32.3
	N_2	30.2	36.0	36.4	35.5	38.0	29.1	*34.2*	P_2	32.8	29.6	30.8
	Mean	*30.2*	*32.8*	*31.1*	*32.8*	*31.0*	*30.2*	*31.3*	±2.61. *Means*: ±*1.51*			
14	N_0	44.3	41.7	48.4	44.3	44.9	45.1	*44.8*	P_0	44.2	48.0	48.7
	N_1	48.7	49.0	54.3	51.6	48.3	52.1	*50.7*	P_1	46.8	45.7	45.6
	N_2	47.8	47.3	46.5	44.2	47.0	50.4	*47.2*	P_2	49.2	46.6	53.4
	Mean	*46.9*	*46.0*	*49.7*	*46.7*	*46.7*	*49.2*	*47.6*	±2.63. *Means* : ±*1.52*			
15	N_0	32.3	28.4	29.7	27.5	28.8	34.1	*30.1*	P_0	34.3	33.7	39.6
	N_1	33.0	35.5	37.5	35.1	36.2	34.7	*35.3*	P_1	34.1	38.4	35.5
	N_2	42.2	44.1	41.1	39.2	45.2	43.0	*42.5*	P_2	33.5	38.1	36.7
	Mean	*35.8*	*36.0*	*36.1*	*33.9*	*36.7*	*37.3*	*36.0*	±2.37. *Means* : ±*1.37*			
16	N_0	17.2	15.9	18.5	15.4	18.0	18.2	*17.2*	P_0	13.4	16.0	17.9
	N_1	15.4	17.5	17.6	14.4	17.0	19.1	*16.8*	P_1	14.7	17.2	18.0
	N_2	14.7	16.4	17.0	14.6	15.8	17.8	*16.1*	P_2	16.3	17.5	19.2
	Mean	*15.7*	*16.6*	*17.7*	*14.8*	*16.9*	*18.3*	*16.7*	±0.970. *Means* : ±*0.560*			
17	N_0	25.6	27.2	27.0	29.0	26.1	24.6	*26.6*	P_0	28.7	24.9	26.8
	N_1	29.8	27.9	31.4	28.6	29.2	31.3	*29.7*	P_1	26.7	28.0	26.2
	N_2	25.0	25.9	27.4	27.0	28.2	23.1	*26.1*	P_2	29.1	30.6	26.0
	Mean	*26.8*	*27.0*	*28.6*	*28.2*	*27.8*	*26.4*	*27.5*	±2.22. *Means* : ±*1.28*			
18	N_0	18.9	18.8	14.2	16.5	14.4	21.0	*17.3*	P_0	15.9	18.2	18.9
	N_1	18.4	17.4	21.4	14.7	18.9	23.6	*19.1*	P_1	16.5	17.9	18.9
	N_2	15.7	17.0	16.2	15.0	16.8	17.1	*16.3*	P_2	13.8	14.1	24.0
	Mean	*17.7*	*17.8*	*17.3*	*15.4*	*16.7*	*20.6*	*17.6*	±2.42. *Means* : ±*1.40*			
19	N_0	36.2	40.0	40.7	43.5	36.9	36.5	*39.0*	P_0	36.2	36.9	32.1
	N_1	32.2	39.9	38.2	34.6	41.2	34.5	*36.8*	P_1	37.5	40.7	39.0
	N_2	36.8	37.3	33.9	32.2	35.6	40.1	*36.0*	P_2	36.6	36.2	40.0
	Mean	*35.1*	*39.0*	*37.6*	*36.8*	*37.9*	*37.0*	*37.2*	±2.12. *Means*: ±*1.22*			
20	N_0	18.9	20.1	19.9	18.0	16.6	24.4	*19.7*	P_0	22.6	20.5	23.9
	N_1	21.5	25.8	22.8	23.9	24.8	21.5	*23.4*	P_1	22.7	23.9	27.7
	N_2	26.4	28.3	32.3	28.6	28.3	30.2	*29.0*	P_2	25.2	25.3	24.5
	Mean	*22.3*	*24.7*	*25.0*	*23.5*	*23.2*	*25.4*	*24.0*	±2.27. *Means*: ±*1.31*			
21 (*a*)	N_0	13.9	16.2	16.8	13.3	17.1	16.6	*15.6*	P_0	13.3	14.9	16.7
	N_1	14.6	15.5	15.5	14.1	14.7	16.6	*15.2*	P_1	15.1	16.3	18.3
	N_2	16.4	18.1	17.7	16.4	17.2	18.6	*17.4*	P_2	15.4	17.8	16.8
	Mean	*15.0*	*16.6*	*16.7*	*14.6*	*16.3*	*17.3*	*16.0*	±0.820. *Means*: ±*0.473*			
22	N_0	26.9	25.0	26.5	26.8	23.8	27.8	*26.1*	P_0	29.2	30.0	30.2
	N_1	30.0	26.7	32.3	27.7	27.8	33.4	*29.6*	P_1	27.3	25.3	29.8
	N_2	32.5	30.7	30.6	31.1	32.2	30.5	*31.3*	P_2	29.0	28.5	31.8
	Mean	*29.8*	*27.5*	*29.8*	*28.5*	*27.9*	*30.6*	*29.0*	±1.78. *Means*: ±*1.03*			

(*a*) At this centre three plots were missing. Only the yields for total sugar adjusted for plant number were analyzed.

Total Sugar : cwt. per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		K_0	K_1	K_2
23	N_0	17.9	22.1	18.9	20.9	18.2	19.8	*19.6*	P_0	22.1	18.5	18.2
	N_1	20.5	21.0	20.8	21.2	20.0	21.1	*20.8*	P_1	20.6	21.6	22.3
	N_2	20.4	21.5	22.8	20.3	22.1	22.1	*21.5*	P_2	19.8	20.2	22.5
	Mean	*19.6*	*21.5*	*20.8*	*20.8*	*20.1*	*21.0*	*20.6*	±1.21. *Means:* ±*0.700*			
24	N_0	11.8	11.5	10.7	10.8	11.9	11.3	*11.3*	P_0	10.8	12.0	10.5
	N_1	11.5	11.4	11.2	10.4	12.1	11.6	*11.4*	P_1	11.7	11.2	10.6
	N_2	10.1	10.5	10.0	10.7	9.7	10.2	*10.2*	P_2	9.5	10.5	11.9
	Mean	*11.1*	*11.1*	*10.6*	*10.7*	*11.2*	*11.0*	*11.0*	±0.664. *Means:* ±*0.383*			
25	N_0	11.8	13.7	14.4	13.1	10.2	16.5	*13.3*	P_0	11.4	11.9	13.7
	N_1	11.8	15.4	16.0	12.9	13.7	16.7	*14.4*	P_1	13.1	13.3	16.1
	N_2	13.2	13.4	12.7	11.1	13.2	15.0	*13.1*	P_2	12.6	11.9	18.5
	Mean	*12.3*	*14.1*	*14.3*	*12.4*	*12.4*	*16.1*	*13.6*	±1.67. *Means:* ±*0.967*			
26	N_0	27.0	32.0	30.2	29.8	29.3	30.1	*29.7*	P_0	26.5	28.0	25.9
	N_1	26.9	31.1	31.4	30.7	31.3	27.4	*29.8*	P_1	30.6	31.7	35.0
	N_2	26.5	34.2	37.6	31.1	32.3	35.0	*32.8*	P_2	34.4	33.2	31.6
	Mean	*26.8*	*32.4*	*33.1*	*30.5*	*31.0*	*30.8*	*30.8*	±1.80. *Means:* ±*1.04*			
27	N_0	22.0	22.6	24.1	20.3	23.8	24.7	*22.9*	P_0	22.1	23.2	25.1
	N_1	26.2	26.3	26.1	27.2	25.2	26.3	*26.2*	P_1	23.8	24.5	24.7
	N_2	22.1	24.0	23.8	22.3	22.6	25.0	*23.3*	P_2	23.9	23.9	26.2
	Mean	*23.4*	*24.3*	*24.7*	*23.3*	*23.9*	*25.3*	*24.2*	±1.12. *Means:* ±*0.647*			
28	N_0	24.6	23.7	24.2	19.8	26.1	26.6	*24.2*	P_0	19.4	26.2	28.4
	N_1	23.1	24.3	30.6	19.3	26.3	32.4	*26.0*	P_1	17.1	25.7	28.5
	N_2	26.2	23.4	24.0	18.3	24.7	30.7	*24.5*	P_2	20.9	25.2	32.7
	Mean	*24.6*	*23.8*	*26.3*	*19.1*	*25.7*	*29.9*	*24.9*	±2.02. *Means:* ±*1.17*			
29	N_0	27.5	24.2	25.4	26.0	24.1	27.0	*25.7*	P_0	29.4	29.2	25.1
	N_1	28.4	29.6	26.2	28.7	27.2	28.3	*28.1*	P_1	26.9	24.5	29.4
	N_2	27.8	27.0	27.5	28.8	25.1	28.4	*27.4*	P_2	27.2	22.8	29.1
	Mean	*27.9*	*26.9*	*26.4*	*27.8*	*25.5*	*27.9*	*27.1*	±1.86. *Means:* ±*1.07*			
30	N_0	50.0	50.5	42.1	44.7	46.2	51.7	*47.6*	P_0	47.2	44.7	52.2
	N_1	46.4	47.2	39.6	43.4	40.1	49.6	*44.4*	P_1	45.4	47.0	48.8
	N_2	47.7	43.5	45.9	43.8	45.3	47.9	*45.7*	P_2	39.4	40.0	48.3
	Mean	*48.0*	*47.1*	*42.5*	*44.0*	*43.9*	*49.8*	*45.9*	±3.27. *Means:* ±*1.89*			
31	N_0	22.9	19.6	31.1	22.1	21.7	29.9	*24.6*	P_0	21.2	19.7	23.6
	N_1	22.7	25.7	20.7	19.7	23.8	25.7	*23.0*	P_1	17.3	21.8	28.1
	N_2	18.7	21.9	17.6	18.4	19.4	20.4	*19.4*	P_2	21.8	23.3	24.4
	Mean	*21.5*	*22.4*	*23.1*	*20.1*	*21.6*	*25.3*	*22.3*	±2.96. *Means:* ±*1.71*			
32	N_0	4.9	11.9	17.2	9.8	10.7	13.4	*11.3*	P_0	8.7	8.2	10.1
	N_1	9.8	12.7	22.0	14.9	16.5	13.1	*14.8*	P_1	12.1	14.6	12.5
	N_2	12.3	14.6	15.4	14.8	14.1	13.4	*14.1*	P_2	18.7	18.5	17.3
	Mean	*9.0*	*13.0*	*18.2*	*13.2*	*13.8*	*13.3*	*13.4*	±1.89. *Means:* ±*1.09*			

Roots (washed) : tons per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		K_0	K_1	K_2
1	N_0	11.41	11.96	11.95	11.12	12.17	12.04	*11.77*	P_0	11.72	12.80	12.89
	N_1	13.47	12.99	12.97	12.89	13.25	13.27	*13.14*	P_1	12.43	12.52	12.48
	N_2	12.53	12.49	12.15	12.23	12.43	12.50	*12.39*	P_2	12.10	12.53	12.44
	Mean	*12.47*	*12.48*	*12.35*	*12.08*	*12.62*	*12.60*	*12.43*				
2	N_0	10.83	10.72	11.59	10.37	11.42	11.36	*11.05*	P_0	9.90	10.92	12.14
	N_1	11.40	11.83	12.40	11.60	11.56	12.48	*11.88*	P_1	10.75	11.03	11.89
	N_2	10.73	11.11	11.10	10.85	11.01	11.09	*10.98*	P_2	12.17	12.04	10.89
	Mean	*10.99*	*11.22*	*11.70*	*10.94*	*11.33*	*11.64*	*11.30*				
3	N_0	3.55	4.38	3.43	3.59	3.79	3.99	*3.79*	P_0	3.26	3.94	4.74
	N_1	3.93	4.49	4.50	3.54	4.08	5.31	*4.31*	P_1	3.64	4.33	4.75
	N_2	4.45	3.85	4.72	3.46	4.72	4.85	*4.34*	P_2	3.68	4.32	4.66
	Mean	*3.98*	*4.24*	*4.22*	*3.53*	*4.20*	*4.72*	*4.15*				
4	N_0	5.87	5.58	5.29	5.53	5.48	5.73	*5.58*	P_0	5.64	6.44	6.02
	N_1	6.20	5.91	5.84	5.47	6.15	6.33	*5.98*	P_1	5.74	6.06	6.43
	N_2	6.03	6.74	6.58	6.25	6.50	6.60	*6.45*	P_2	5.87	5.63	6.21
	Mean	*6.03*	*6.08*	*5.90*	*5.75*	*6.04*	*6.22*	*6.00*				
5	N_0	5.33	6.53	6.18	4.70	6.45	6.90	*6.02*	P_0	4.12	6.15	7.16
	N_1	5.95	7.23	6.94	5.15	7.13	7.84	*6.70*	P_1	5.17	7.17	7.67
	N_2	6.15	6.24	6.27	4.36	6.44	7.86	*6.22*	P_2	4.93	6.69	7.77
	Mean	*5.81*	*6.67*	*6.46*	*4.74*	*6.67*	*7.53*	*6.31*				
6	N_0	3.98	4.35	4.91	4.28	4.66	4.30	*4.41*	P_0	4.42	4.82	5.11
	N_1	5.29	4.92	5.23	4.74	5.10	5.60	*5.14*	P_1	4.68	5.21	5.19
	N_2	5.08	5.81	5.45	4.67	5.39	6.27	*5.45*	P_2	4.60	5.12	5.87
	Mean	*4.78*	*5.03*	*5.19*	*4.56*	*5.05*	*5.39*	*5.00*				
7	N_0	6.40	6.39	6.44	6.49	6.15	6.60	*6.41*	P_0	5.66	6.23	6.23
	N_1	6.41	5.36	5.69	5.60	5.87	6.00	*5.82*	P_1	6.11	5.74	5.57
	N_2	5.30	5.66	5.92	5.73	5.75	5.39	*5.62*	P_2	6.05	5.81	6.19
	Mean	*6.04*	*5.80*	*6.02*	*5.94*	*5.92*	*6.00*	*5.95*				
8	N_0	5.90	6.59	7.35	5.35	6.74	7.75	*6.61*	P_0	6.38	7.59	8.36
	N_1	7.83	8.89	9.23	6.80	8.80	10.35	*8.65*	P_1	6.35	8.56	9.88
	N_2	8.60	9.32	8.92	7.07	9.55	10.21	*8.94*	P_2	6.50	8.94	10.07
	Mean	*7.44*	*8.26*	*8.50*	*6.41*	*8.36*	*9.44*	*8.07*				
9	N_0	6.91	7.37	5.81	7.02	6.31	6.77	*6.70*	P_0	9.50	8.59	9.59
	N_1	9.75	10.58	10.08	10.75	9.88	9.77	*10.13*	P_1	10.07	9.87	9.33
	N_2	11.01	11.32	10.21	10.47	11.07	10.99	*10.84*	P_2	8.67	8.81	8.62
	Mean	*9.22*	*9.76*	*8.70*	*9.41*	*9.09*	*9.18*	*9.23*				
10	N_0	12.54	13.55	12.54	13.13	12.89	12.60	*12.88*	P_0	11.56	13.33	12.99
	N_1	12.99	12.86	12.62	11.78	13.37	13.31	*12.82*	P_1	12.85	12.98	12.74
	N_2	12.36	12.16	13.13	12.00	12.82	12.83	*12.55*	P_2	12.50	12.77	13.01
	Mean	*12.63*	*12.86*	*12.76*	*12.30*	*13.03*	*12.92*	*12.75*				
11	N_0	6.33	7.79	8.25	7.04	7.89	7.43	*7.46*	P_0	7.75	8.62	7.46
	N_1	8.89	8.04	7.37	8.27	8.04	8.00	*8.10*	P_1	7.12	8.56	9.64
	N_2	8.60	9.50	8.96	8.08	9.79	9.18	*9.02*	P_2	8.52	8.54	7.52
	Mean	*7.94*	*8.44*	*8.19*	*7.80*	*8.57*	*8.20*	*8.19*				

Roots (washed) : tons per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		K_0	K_1	K_2
12	N_0	12.24	13.28	13.60	13.40	12.36	13.36	*13.04*	P_0	13.20	13.04	12.96
	N_1	13.51	13.43	13.36	12.92	13.50	13.88	*13.44*	P_1	12.96	13.23	14.19
	N_2	13.45	13.67	14.14	13.16	13.82	14.27	*13.75*	P_2	13.33	13.40	14.36
	Mean	*13.07*	*13.46*	*13.70*	*13.16*	*13.23*	*13.84*	*13.41*				
13	N_0	8.73	8.92	6.46	8.80	7.35	7.96	*8.04*	P_0	9.56	8.97	8.12
	N_1	8.93	9.68	10.12	9.65	9.01	10.07	*9.58*	P_1	9.85	9.89	9.60
	N_2	8.99	10.73	10.54	10.54	11.06	8.65	*10.08*	P_2	9.58	8.57	8.96
	Mean	*8.88*	*9.78*	*9.04*	*9.66*	*9.14*	*8.89*	*9.23*				
14	N_0	13.34	12.43	14.52	13.37	13.35	13.58	*13.43*	P_0	13.36	14.36	14.61
	N_1	14.69	14.31	15.88	15.23	14.36	15.29	*14.96*	P_1	13.89	13.47	13.61
	N_2	14.30	14.24	14.46	13.58	14.22	15.20	*14.33*	P_2	14.93	14.09	15.84
	Mean	*14.11*	*13.66*	*14.95*	*14.06*	*13.98*	*14.69*	*14.24*				
15	N_0	9.39	8.28	8.80	8.23	8.45	9.79	*8.82*	P_0	10.32	9.93	11.30
	N_1	9.73	10.34	11.00	10.46	10.55	10.05	*10.36*	P_1	10.08	11.17	10.30
	N_2	12.43	12.93	12.22	11.90	13.34	12.34	*12.52*	P_2	10.19	11.24	10.59
	Mean	*10.52*	*10.52*	*10.67*	*10.20*	*10.78*	*10.73*	*10.57*				
16	N_0	5.27	4.91	5.52	4.83	5.46	5.41	*5.23*	P_0	4.28	5.04	5.24
	N_1	4.77	5.16	5.22	4.57	5.07	5.51	*5.05*	P_1	4.56	5.18	5.35
	N_2	4.52	5.01	5.18	4.46	4.91	5.35	*4.90*	P_2	5.01	5.22	5.68
	Mean	*4.86*	*5.03*	*5.30*	*4.62*	*5.14*	*5.42*	*5.06*				
17	N_0	7.97	8.22	8.09	8.61	7.90	7.77	*8.09*	P_0	8.73	7.59	8.44
	N_1	8.82	8.81	9.37	8.60	8.83	9.56	*9.00*	P_1	8.25	9.01	8.29
	N_2	7.97	8.52	8.58	8.59	8.98	7.51	*8.36*	P_2	8.82	9.11	8.12
	Mean	*8.25*	*8.52*	*8.68*	*8.60*	*8.57*	*8.28*	*8.48*				
18	N_0	6.33	6.36	4.82	5.70	4.90	6.90	*5.84*	P_0	5.57	6.31	6.21
	N_1	6.27	6.08	7.40	5.27	6.60	7.88	*6.58*	P_1	5.87	6.19	6.47
	N_2	5.49	6.08	5.85	5.47	5.95	6.00	*5.81*	P_2	5.01	4.95	8.11
	Mean	*6.03*	*6.18*	*6.02*	*5.48*	*5.82*	*6.93*	*6.08*				
19	N_0	10.79	12.31	11.72	12.55	11.52	10.75	*11.61*	P_0	10.81	11.29	9.36
	N_1	9.71	11.77	11.42	10.51	11.94	10.45	*10.96*	P_1	10.92	12.30	11.87
	N_2	10.96	11.02	9.96	9.48	10.76	11.69	*10.65*	P_2	10.82	10.63	11.66
	Mean	*10.48*	*11.70*	*11.03*	*10.85*	*11.41*	*10.96*	*11.07*				
20	N_0	5.17	5.37	5.48	4.86	4.52	6.63	*5.34*	P_0	6.22	5.57	6.56
	N_1	5.83	7.18	6.30	6.52	6.91	5.88	*6.44*	P_1	6.17	6.61	7.47
	N_2	7.35	7.71	8.91	7.89	7.76	8.31	*7.99*	P_2	6.89	7.01	6.79
	Mean	*6.11*	*6.75*	*6.90*	*6.42*	*6.40*	*6.94*	*6.59*				
22	N_0	8.07	7.33	7.97	8.01	7.14	8.23	*7.79*	P_0	8.74	8.83	8.84
	N_1	8.82	8.08	9.50	8.36	8.29	9.75	*8.80*	P_1	8.08	7.56	8.74
	N_2	9.52	8.97	9.03	9.08	9.53	8.91	*9.17*	P_2	8.63	8.57	9.31
	Mean	*8.80*	*8.12*	*8.84*	*8.48*	*8.32*	*8.96*	*8.59*				

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Roots (washed) : tons per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		K_0	K_1	K_2
23	N_0	5.83	6.99	6.22	6.76	5.84	6.44	*6.34*	P_0	7.34	6.09	5.98
	N_1	6.80	6.97	6.81	7.04	6.55	6.99	*6.86*	P_1	6.80	7.03	7.38
	N_2	6.78	7.25	7.46	6.87	7.29	7.33	*7.16*	P_2	6.53	6.56	7.40
	Mean	*6.47*	*7.07*	*6.83*	*6.89*	*6.56*	*6.92*	*6.79*				
24	N_0	4.00	3.94	3.65	3.76	4.05	3.78	*3.86*	P_0	3.84	4.24	3.67
	N_1	4.02	4.13	3.91	3.69	4.22	4.16	*4.02*	P_1	4.07	3.91	3.78
	N_2	3.73	3.69	3.58	3.80	3.62	3.58	*3.67*	P_2	3.34	3.74	4.07
	Mean	*3.92*	*3.92*	*3.71*	*3.75*	*3.96*	*3.84*	*3.85*				
25	N_0	3.46	4.06	4.13	3.94	3.02	4.68	*3.88*	P_0	3.41	3.53	4.00
	N_1	3.50	4.64	4.77	3.91	4.16	4.84	*4.30*	P_1	3.98	4.07	4.74
	N_2	3.98	4.09	4.03	3.47	4.13	4.51	*4.04*	P_2	3.93	3.71	5.29
	Mean	*3.65*	*4.26*	*4.31*	*3.77*	*3.77*	*4.68*	*4.07*				
26	N_0	7.90	9.11	8.78	8.66	8.52	8.60	*8.59*	P_0	8.04	8.40	7.76
	N_1	8.05	9.10	9.08	9.09	9.04	8.10	*8.74*	P_1	9.15	9.27	10.12
	N_2	8.24	10.33	11.03	9.47	9.70	10.44	*9.87*	P_2	10.04	9.58	9.26
	Mean	*8.06*	*9.52*	*9.63*	*9.08*	*9.08*	*9.05*	*9.07*				
27	N_0	6.67	7.02	7.45	6.31	7.27	7.56	*7.05*	P_0	6.92	7.32	7.71
	N_1	8.05	8.33	8.03	8.38	8.05	7.99	*8.14*	P_1	7.50	7.92	7.74
	N_2	7.23	7.81	7.80	7.28	7.47	8.09	*7.62*	P_2	7.55	7.55	8.18
	Mean	*7.32*	*7.72*	*7.76*	*7.32*	*7.60*	*7.88*	*7.60*				
28	N_0	7.26	6.83	7.09	5.90	7.59	7.68	*7.06*	P_0	5.84	7.81	8.36
	N_1	6.87	7.20	9.35	5.97	7.86	9.59	*7.81*	P_1	5.22	7.57	8.40
	N_2	7.88	7.17	7.44	5.68	7.49	9.32	*7.50*	P_2	6.50	7.56	9.83
	Mean	*7.33*	*7.07*	*7.96*	*5.85*	*7.65*	*8.86*	*7.45*				
29	N_0	8.88	7.88	8.39	8.48	7.96	8.71	*8.38*	P_0	9.88	9.38	8.20
	N_1	9.38	9.81	8.75	9.46	8.99	9.48	*9.31*	P_1	8.87	8.17	9.62
	N_2	9.21	8.98	9.15	9.59	8.47	9.29	*9.11*	P_2	8.77	7.87	9.65
	Mean	*9.16*	*8.89*	*8.76*	*9.17*	*8.48*	*9.16*	*8.94*				
30	N_0	15.83	16.04	13.57	14.41	14.55	16.48	*15.15*	P_0	14.88	14.20	16.44
	N_1	14.67	14.87	12.75	13.82	12.87	15.59	*14.10*	P_1	14.69	14.84	15.48
	N_2	15.01	14.11	14.75	14.06	14.46	15.36	*14.62*	P_2	12.72	12.84	15.51
	Mean	*15.17*	*15.01*	*13.69*	*14.10*	*13.96*	*15.81*	*14.62*				
31	N_0	6.35	5.54	8.43	6.26	5.96	8.11	*6.78*	P_0	5.98	5.46	6.53
	N_1	6.36	7.24	5.85	5.59	6.65	7.20	*6.48*	P_1	5.00	6.22	7.81
	N_2	5.26	6.25	5.04	5.27	5.53	5.75	*5.52*	P_2	6.14	6.46	6.72
	Mean	*5.99*	*6.34*	*6.44*	*5.70*	*6.05*	*7.02*	*6.26*				
32	N_0	1.84	4.73	6.45	3.85	4.13	5.04	*4.34*	P_0	3.50	3.25	3.83
	N_1	3.92	4.96	8.23	5.81	6.15	5.16	*5.70*	P_1	4.77	5.60	5.03
	N_2	4.82	5.71	6.11	5.83	5.56	5.25	*5.55*	P_2	7.22	7.00	6.57
	Mean	*3.53*	*5.13*	*6.93*	*5.16*	*5.28*	*5.15*	*5.20*				

Tops : tons per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		K_0	K_1	K_2
1	N_0	11.48	10.54	10.13	11.18	10.22	10.75	*10.72*	P_0	12.33	13.29	10.37
	N_1	11.36	12.12	12.27	13.06	12.33	10.37	*11.92*	P_1	13.50	12.62	11.07
	N_2	13.15	14.52	12.53	13.09	13.70	13.41	*13.40*	P_2	11.51	10.34	13.09
	Mean	*12.00*	*12.40*	11.64	*12.44*	*12.08*	*11.51*	*12.01*	±1.13. *Means :* ±*0.650*			
2	N_0	9.98	9.92	12.42	10.95	11.57	9.81	*10.77*	P_0	11.71	12.41	10.98
	N_1	13.76	11.48	12.53	13.35	11.80	12.62	*12.59*	P_1	12.80	11.45	11.45
	N_2	11.36	14.29	13.12	13.24	12.24	13.30	*12.92*	P_2	13.03	11.74	13.29
	Mean	*11.70*	*11.90*	*12.69*	*12.51*	*11.87*	*11.91*	*12.10*	±1.08. *Means:* ±*0.623*			
3	N_0	5.48	5.33	5.24	5.49	5.41	5.15	*5.35*	P_0	6.76	6.80	6.87
	N_1	6.77	6.93	7.14	7.39	6.52	6.93	*6.95*	P_1	7.21	7.21	6.17
	N_2	8.18	8.33	9.13	8.50	9.35	7.78	*8.55*	P_2	7.41	7.27	6.83
	Mean	*6.81*	*6.86*	*7.17*	*7.13*	*7.09*	*6.62*	*6.95*	±0.400. *Means:* ±*0.231*			
4	N_0	5.11	4.96	4.73	5.04	4.76	4.98	*4.93*	P_0	6.68	6.56	6.09
	N_1	6.50	6.17	6.24	6.21	6.61	6.09	*6.30*	P_1	6.40	6.55	6.40
	N_2	7.72	8.23	8.79	8.98	8.04	7.72	*8.24*	P_2	7.16	6.31	6.29
	Mean	*6.44*	*6.45*	*6.59*	*6.75*	*6.47*	*6.26*	*6.49*	±0.224. *Means:* ±*0.158*			
5	N_0	8.54	7.92	9.61	7.46	8.82	9.79	*8.69*	P_0	9.16	12.78	13.18
	N_1	12.50	12.44	11.25	8.60	12.55	15.04	*12.06*	P_1	9.39	11.59	11.93
	N_2	14.08	12.56	11.71	10.24	13.91	14.20	*12.78*	P_2	7.75	10.91	13.91
	Mean	*11.71*	*10.97*	*10.86*	*8.77*	*11.76*	*13.01*	*11.18*	±0.930. *Means:* ±*0.537*			
6	N_0	5.15	5.20	4.94	5.25	5.25	4.79	*5.10*	P_0	6.69	6.12	6.09
	N_1	5.88	6.72	6.95	7.19	6.20	6.16	*6.52*	P_1	7.01	6.77	6.69
	N_2	7.87	8.55	9.07	8.83	8.76	7.91	*8.50*	P_2	7.57	7.32	6.08
	Mean	*6.30*	*6.82*	*6.99*	*7.09*	*6.74*	*6.29*	*6.70*	±0.400. *Means:* ±*0.231*			
7	N_0	5.24	5.04	4.52	5.02	4.74	5.04	*4.93*	P_0	5.95	5.72	5.61
	N_1	5.99	4.88	5.18	5.24	5.41	5.39	*5.35*	P_1	5.22	5.41	5.21
	N_2	6.06	5.92	7.01	6.37	6.53	6.09	*6.33*	P_2	5.45	5.55	5.71
	Mean	*5.76*	*5.28*	*5.57*	*5.54*	*5.56*	*5.51*	*5.54*	±0.387. *Means:* ±*0.223*			
8	N_0	6.61	6.33	7.63	6.02	7.30	7.25	*6.86*	P_0	7.83	9.40	9.56
	N_1	8.85	10.21	9.74	8.12	10.21	10.46	*9.60*	P_1	7.97	10.01	10.14
	N_2	11.32	11.58	12.68	10.22	12.29	13.07	*11.86*	P_2	8.56	10.39	11.09
	Mean	*8.93*	*9.37*	*10.01*	*8.12*	*9.93*	*10.26*	*9.44*	±0.391. *Means:* ±*0.226*			
9	N_0	5.81	5.74	4.17	5.50	4.64	5.57	*5.24*	P_0	8.79	7.94	9.95
	N_1	9.05	9.20	9.09	9.17	8.67	9.49	*9.11*	P_1	9.10	9.59	9.36
	N_2	11.81	13.11	10.92	11.45	12.48	11.92	*11.95*	P_2	8.23	8.27	7.68
	Mean	*8.89*	*9.35*	*8.06*	*8.71*	*8.60*	*9.00*	*8.77*	±0.670. *Means:* ±*0.387*			
10	N_0	8.50	11.88	9.29	11.68	9.29	8.70	*9.89*	P_0	10.33	11.48	11.24
	N_1	10.41	9.97	11.76	9.69	11.40	11.04	*10.71*	P_1	12.43	11.92	9.89
	N_2	14.14	12.39	12.11	12.71	13.74	12.19	*12.88*	P_2	11.32	11.04	10.80
	Mean	*11.02*	*11.41*	*11.06*	*11.36*	*11.48*	*10.64*	*11.16*	±1.34. *Means:* ±*0.773*			
11	N_0	5.71	6.23	6.20	5.83	6.66	5.64	*6.04*	P_0	7.54	7.58	6.47
	N_1	7.60	7.04	6.93	8.18	6.77	6.62	*7.19*	P_1	6.77	7.43	7.48
	N_2	8.29	8.41	8.37	8.31	8.83	7.93	*8.36*	P_2	8.02	7.25	6 25
	Mean	*7.20*	*7.22*	*7.17*	*7.44*	*7.42*	*6.73*	*7.20*	±0.572. *Means:* ±*0.330*			

Tops : tons per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		K_0	K_1	K_2
12	N_0	13.33	12.20	13.27	14.05	11.67	13.09	*12.94*	P_0	16.13	15.00	14.29
	N_1	14.29	14.41	13.15	13.16	14.11	14.58	*13.95*	P_1	13.81	14.17	14.88
	N_2	17.80	16.25	16.73	16.55	17.85	16.37	*16.92*	P_2	13.81	14.46	14.88
	Mean	*15.14*	*14.28*	*14.38*	*14.58*	*14.54*	*14.68*	*14.60*	±0.785. *Means : ±0.453*			
13	N_0	8.00	8.27	6.23	7.63	7.03	7.83	*7.50*	P_0	11.02	9.92	10.41
	N_1	9.83	9.80	9.95	10.15	9.08	10.35	*9.86*	P_1	11.18	10.25	10.42
	N_2	13.52	13.78	14.70	14.34	14.49	13.17	*14.00*	P_2	9.92	10.43	10.53
	Mean	*10.45*	*10.62*	*10.29*	*10.71*	*10.20*	*10.45*	*10.45*	±0.733. *Means: ±0.423*			
14	N_0	10.91	10.71	11.88	10.77	11.20	11.53	*11.16*	P_0	12.29	14.06	13.41
	N_1	14.25	13.28	13.82	13.93	13.89	13.53	*13.78*	P_1	12.83	12.78	12.73
	N_2	14.60	14.35	16.20	14.15	15.17	15.83	*15.05*	P_2	13.73	13.41	14.75
	Mean	*13.25*	*12.78*	*13.97*	*12.95*	*13.42*	*13.63*	*13.33*	±0.791. *Means: ±0.457*			
15	N_0	7.11	7.04	7.28	6.50	6.45	8.47	*7.14*	P_0	8.17	8.82	9.39
	N_1	8.87	8.57	9.24	9.25	8.75	8.68	*8.89*	P_1	9.03	8.68	9.16
	N_2	10.40	11.26	10.14	9.29	11.75	10.76	*10.60*	P_2	7.84	9.45	9.37
	Mean	*8.79*	*8.96*	*8.89*	*8.35*	*8.98*	*9.30*	*8.88*	±0.751. *Means: ±0.433*			
16	N_0	5.17	4.90	5.13	5.10	5.09	5.00	*5.06*	P_0	5.04	5.06	5.14
	N_1	5.04	5.40	5.71	4.90	5.63	5.61	*5.38*	P_1	5.02	5.29	5.58
	N_2	5.04	5.59	5.64	5.46	5.13	5.68	*5.42*	P_2	5.39	5.51	5.57
	Mean	*5.08*	*5.30*	*5.49*	*5.15*	*5.28*	*5.43*	*5.29*	±0.267. *Means: ±0.154*			
17	N_0	10.16	8.33	7.50	9.86	7.40	8.73	*8.66*	P_0	11.71	8.52	11.71
	N_1	11.28	9.19	9.32	10.02	9.46	10.31	*9.93*	P_1	10.21	10.05	9.32
	N_2	10.50	12.06	12.89	10.72	12.00	12.73	*11.82*	P_2	8.68	10.29	10.74
	Mean	*10.64*	*9.86*	*9.90*	*10.20*	*9.62*	*10.59*	*10.14*	±1.11. *Means: ±0.643*			
19	N_0	11.56	12.45	11.37	14.03	12.95	8.42	*11.80*	P_0	13.99	13.78	10.34
	N_1	12.50	15.23	12.77	14.81	13.31	12.38	*13.50*	P_1	14.39	13.57	14.12
	N_2	14.05	14.40	11.49	12.03	14.47	13.43	*13.31*	P_2	12.48	13.38	9.77
	Mean	*12.70*	*14.03*	*11.88*	*13.62*	*13.58*	*11.41*	*12.87*	±0.947. *Means: ±0.547*			
20	N_0	4.01	3.67	3.84	3.44	3.41	4.66	*3.84*	P_0	5.94	4.74	5.65
	N_1	5.49	4.76	4.86	5.77	4.95	4.40	*5.04*	P_1	5.05	4.81	4.88
	N_2	6.83	6.31	7.83	7.26	6.79	6.92	*6.90*	P_2	5.48	5.60	5.45
	Mean	*5.44*	*4.91*	*5.51*	*5.49*	*5.05*	*5.32*	*5.29*	±0.519. *Means: ±0.300*			
22	N_0	7.03	7.77	6.65	6.60	8.05	6.79	*7.15*	P_0	8.03	6.38	8.91
	N_1	8.70	7.89	9.93	9.24	7.79	9.48	*8.84*	P_1	8.91	8.81	8.06
	N_2	7 60	10 13	8.43	8.15	8.12	9.89	*8.72*	P_2	7.05	8.77	9.20
	Mean	*7.77*	*8.59*	*8.34*	*8.00*	*7.99*	*8.72*	*8.23*	±1.14. *Means: ±0.657*			

Tops: tons per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		K_0	K_1	K_2
24	N_0	5.09	5.06	4.87	4.55	5.44	5.02	*5.00*	P_0	5.40	6.02	5.46
	N_1	5.86	6.02	5.46	5.18	6.26	5.90	*5.76*	P_1	5.22	6.15	5.51
	N_2	5.93	5.79	5.77	5.86	6.02	5.62	*5.83*	P_2	4.98	5.55	5.57
	Mean	*5.62*	*5.61*	*5.37*	*5.20*	*5.89*	*5.51*	*5.54*	±0.240. *Means: ±0.139*			
25	N_0	3.17	3.70	3.86	3.65	3.48	3.59	*3.57*	P_0	4.34	4.29	3.91
	N_1	4.39	4.88	4.40	4.50	4.50	4.66	*4.55*	P_1	4.07	4.50	4.61
	N_2	4.98	4.61	4.93	4.50	5.25	4.77	*4.84*	P_2	4.23	4.45	4.50
	Mean	*4.18*	*4.39*	*4.39*	*4.22*	*4.41*	*4.34*	*4.32*	±0.241. *Means: ±0.139*			
27	N_0	5.03	6.23	6.15	5.08	6.44	5.89	*5.80*	P_0	6.60	6.89	5.89
	N_1	7.55	8.17	6.44	8.02	7.96	6.18	*7.39*	P_1	7.65	8.20	6.78
	N_2	6.81	8.22	8.48	8.33	6.92	8.27	*7.84*	P_2	7.18	6.23	7.67
	Mean	*6.46*	*7.54*	*7.03*	*7.14*	*7.11*	*6.78*	*7.01*	±0.849. *Means:* ±0.490			
28	N_0	6.79	5.87	7.02	6.72	6.95	6.01	*6.56*	P_0	7.18	9.14	8.53
	N_1	8.38	8.19	11.09	8.28	8.97	10.41	*9.22*	P_1	7.46	8.18	8.38
	N_2	9.68	9.95	9.96	8.88	9.90	10.81	*9.86*	P_2	9.24	8.51	10.32
	Mean	*8.28*	*7.99*	*9.36*	*7.96*	*8.61*	*9.08*	*8.55*	±0.710. *Means:* ±0.410			
29	N_0	12.43	10.90	12.64	12.91	11.23	11.83	*11.99*	P_0	13.42	13.47	12.04
	N_1	12.49	14.16	11.89	12.49	13.09	12.96	*12.84*	P_1	11.95	12.73	14.04
	N_2	14.01	13.65	14.34	13.89	13.50	14.61	*14.00*	P_2	13.92	11.62	13.32
	Mean	*12.98*	*12.90*	*12.96*	*13.10*	*12.61*	*13.13*	*12.94*	±1.42. *Means: ±0.820*			
30	N_0	20.95	19.83	21.22	21.48	20.21	20.30	*20.67*	P_0	21.38	20.97	20.47
	N_1	20.30	20.54	20.01	20.30	20.50	20.06	*20.29*	P_1	19.86	20.12	20.53
	N_2	21.56	20.13	21.87	21.28	21.47	20.81	*21.19*	P_2	21.82	21.10	20.18
	Mean	*20.94*	*20.17*	*21.03*	*21.02*	*20.73*	*20.39*	*20.71*	±0.681. *Means: ±0.393*			
31	N_0	11.00	10.83	10.65	11.30	10.42	10.77	*10.83*	P_0	10.83	10.65	9.48
	N_1	10.13	12.06	11.30	11.94	10.54	11.00	*11.16*	P_1	10.89	10.71	12.23
	N_2	9.83	10.95	11.00	9.60	11.36	10.83	*10.60*	P_2	11.12	10.95	10.89
	Mean	*10.32*	*11.28*	*10.98*	*10.95*	*10.77*	*10.87*	*10.86*	±0.670. *Means: ±0.387*			
32	N_0	5.72	8.89	15.16	8.75	9.20	11.82	*9.92*	P_0	8.00	8.48	9.28
	N_1	9.38	11.72	15.59	11.66	12.67	12.35	*12.23*	P_1	10.18	11.17	11.87
	N_2	10.66	12.62	13.52	13.20	12.46	11.13	*12.26*	P_2	15.43	14.69	14.15
	Mean	*8.59*	*11.07*	*14.76*	*11.20*	*11.44*	*11.77*	*11.47*	±1.24. *Means: ±0.713*			

Responses to Fertilizers

*5 per cent. significance. **1 per cent significance.

Station	*Mean yield*	Linear Response (response to the double dressing)			St. error	Curvature (excess of extra response to second dressing over response to first dressing)			St. error
		N	P	K		N	P	K	
		TOTAL SUGAR : cwt. per acre							
COARSE SANDS									
1 Allscott I (a) ..	*42.2*	+1.8	−1.2	+1.9	±0.981	−6.8**	−2.6	−2.0	±1.70
2 Allscott II ..	*37.3*	+0.5	+2.4*	+3.6**	±1.07	−6.6**	+0.8	−0.6	±1.85
3 Cantley I (a) ..	*12.1*	+1.2	−0.1	+2.6**	±0.655	0.0	+0.6	+0.2	±1.13
4 Cantley II ..	*18.6*	+2.2**	−0.5	+1.9*	±0.725	0.0	−0.7	−0.7	±1.25
5 Colwick ..	*20.5*	+0.4	+2.0**	+10.0**	±0.641	−3.8**	−3.9**	−3.4**	±1.11
6 King's Lynn I	*15.6*	+2.5**	+1.6*	+3.0**	±0.712	−1.3	−0.5	−0.2	±1.23
7 King's Lynn II (a)	*18.4*	−3.1**	−0.3	+1.4	±0.731	+1.9	+0.1	−1.4	±1.27
8 Newark I ..	*28.2*	+7.7**	+3.7**	+11.5**	±0.929	−7.3**	−1.9	−4.0*	±1.61
9 Selby I ..	*30.0*	+14.1**	−2.4	−0.9	±1.41	−9.1**	−5.5*	+0.7	±2.44
10 Wissington I (a)	*42.2*	−1.1	0.0	+3.7*	±1.34	−1.8	−0.6	−2.5	±2.32
11 Wissington III (a)	*26.5*	+5.3*	−1.4	+2.8	±1.84	+0.5	−2.6	−2.2	±3.18
Mean	*26.5*	*+2.9*	*+0.3*	*+3.8*		*−3.1*	*−1.5*	*−1.5*	
FINE SANDS									
12 Bardney I ..	*44.5*	+1.4	+2.1	+3.3*	±1.13	−0.4	+0.2	+1.7	±1.96
13 Bardney II (a)	*31.3*	+4.7*	+3.6	−1.4	±1.71	−1.4	−6.2	+1.8	±2.96
14 Brigg I (a) ..	*47.6*	+2.0	+2.9	+2.2	±1.78	−6.1	+4.9	+4.2	±3.08
15 Brigg II ..	*36.0*	+12.3**	+0.2	+3.3	±1.93	+1.9	−0.1	−2.3	±3.35
16 Bury II ..	*16.7*	−1.1	+1.9*	+3.6**	±0.792	−0.4	+0.2	−0.7	±1.37
17 Cupar I ..	*27.5*	−0.5	+1.8	−1.8	±1.81	−6.7*	+1.4	−1.1	±3.14
18 Ipswich I (a) ..	*17.6*	+0.2	0.0	+5.3**	±1.67	−4.4	+4.5	+5.7	±2.90
19 Kidderminster	*37.2*	−3.0	+2.5	+0.3	±1.73	+1.4	−5.4	−2.1	±3.00
20 Poppleton ..	*24.0*	+9.4**	+2.7	+1.8	±1.85	+1.9	−2.1	+2.5	±3.21
Mean	*31.4*	*+2.8*	*+2.0*	*+1.8*		*−1.6*	*−0.3*	*+1.1*	
LIGHT LOAMS									
21 Bury I (a)	*16.1*	+1.8*	+1.7*	+2.7**	±0.668	+2.7*	−1.6	−0.8	±1.15
22 Cupar II ..	*29.0*	+5.1**	0.0	+2.1	±1.45	−1.9	+4.6	+3.2	±2.51
23 Ipswich II (a) ..	*20.6*	+1.4	+1.0	+0.6	±0.820	−1.2	−1.9	+1.5	±1.42
24 Oaklands II ..	*11.0*	−1.1	−0.5	+0.4	±0.542	−1.2	−0.5	−0.8	±0.939
25 Spalding I (a) ..	*13.6*	+0.3	+2.0*	+4.1**	±0.834	−1.0	−1.0	+1.0	±1.45
Mean	*18.1*	*+1.5*	*+0.8*	*+2.0*		*−0.5*	*−0.1*	*+0.8*	
HEAVY LOAM									
26 Peterboro' I (a)	*30.8*	+2.6*	+6.2**	+0.9	±1.12	−0.4	−3.3	−0.3	±1.94
CLAY LOAMS									
27 Felstead ..	*24.2*	+0.4	+1.2	+2.1*	±0.915	−6.3**	−0.5	+0.8	±1.58
28 Oaklands I ..	*24.9*	+0.4	+1.6	+10.8**	±1.65	−3.3	+3.3	−2.4	±2.86
29 Selby II (a) ..	*27.1*	+0.6	−1.3	0.0	±1.31	−2.1	+0.8	+3.9	±2.26
Mean	*25.4*	*+0.5*	*+0.5*	*+4.3*		*−3.9*	*+1.2*	*+0.8*	
FENS									
30 Ely ..	*45.9*	−3.0	−7.0**	+6.8**	±2.08	+4.0	−5.0	+3.0	±3.60
31 Peterboro' II ..	*22.3*	−5.2*	+1.7	+5.3*	±2.42	−2.1	−0.2	+2.2	±4.19
32 Wissington II (a)	*13.4*	+1.7	+7.9**	−1.3	±1.32	−0.8	+1.2	−4.2	±2.29
Mean	*27.2*	−2.2	+0.9	+3.6		*+0.4*	*−1.3*	*+0.3*	
Mean	*26.7*	*+1.9*	*+1.1*	*+2.9*		*−1.9*	*−0.7*	*0.0*	

(a) = adjusted for Plant Number.

Station	*Mean yield*	Linear Response (response to the double dressing)			Curvature (excess of extra response to second dressing over response to first dressing)		
		N	P	K	N	P	K
	ROOTS (washed) : tons per acre						
COARSE SANDS							
1 Allscott I	*12.43*	+0.62	−0.11	+0.52	−2.12	−0.13	−0.55
2 Allscott II	*11.30*	−0.06	+0.71	+0.70	−1.73	+0.24	−0.08
3 Cantley I	*4.15*	+0.55	+0.24	+1.19	−0.49	−0.28	−0.15
4 Cantley II	*6.00*	+0.87	−0.13	+0.47	+0.07	−0.23	−0.11
5 Colwick	*6.31*	+0.20	+0.65	+2.80	−1.17	−1.06	−1.08
6 King's Lynn I	*5.00*	+1.03	+0.41	+0.82	−0.43	−0.08	−0.15
7 King's Lynn II	*5.95*	−0.79	−0.02	+0.06	+0.40	+0.44	+0.09
8 Newark I	*8.07*	+2.33	+1.06	+3.03	−1.74	−0.59	−0.88
9 Selby I	*9.23*	+4.14	−0.52	−0.23	−2.72	−1.59	+0.42
10 Wissington I	*12.75*	−0.32	+0.13	+0.61	−0.22	−0.32	−0.83
11 Wissington III	*8.19*	+1.56	+0.25	+0.41	+0.27	−0.75	−1.14
Mean	*8.13*	*+0.92*	*+0.24*	*+0.94*	*−0.90*	*−0.40*	*−0.41*
FINE SANDS							
12 Bardney I	*13.41*	+0.71	+0.63	+0.68	−0.09	−0.15	+0.54
13 Bardney II	*9.23*	+2.05	+0.15	−0.77	−1.04	−1.63	+0.27
14 Brigg I	*14.24*	+0.90	+0.84	+0.63	−2.16	+1.75	+0.80
15 Brigg II	*10.57*	+3.70	+0.16	+0.53	+0.64	+0.16	−0.64
16 Bury II	*5.06*	−0.33	+0.45	+0.80	+0.04	+0.10	−0.25
17 Cupar I	*8.48*	+0.27	+0.43	−0.32	−1.54	−0.10	−0.26
18 Ipswich I	*6.08*	−0.03	−0.01	+1.45	−1.52	−0.30	+0.77
19 Kidderminster	*11.07*	−0.96	+0.55	+0.12	+0.32	−1.88	−1.00
20 Poppleton	*6.59*	+2.65	+0.78	+0.52	+0.46	−0.49	+0.57
Mean	*9.41*	*+1.00*	*+0.44*	*+0.40*	*−0.54*	*−0.28*	*+0.09*
LIGHT LOAMS							
22 Cupar II	*8.59*	+1.38	+0.03	+0.48	−0.64	+1.39	+0.81
23 Ipswich II	*6.79*	+0.82	+0.36	+0.03	−0.21	−0.84	+0.69
24 Oaklands II	*3.85*	−0.19	−0.20	+0.09	−0.52	−0.21	−0.34
25 Spalding I	*4.07*	+0.16	+0.66	+0.90	−0.69	−0.57	+0.91
Mean	*5.82*	*+0.54*	*+0.21*	*+0.38*	*−0.52*	*−0.06*	*+0.52*
HEAVY LOAM							
26 Peterboro' I	*9.07*	+1.28	+1.56	−0.03	+0.98	−1.34	−0.05
CLAY LOAMS							
27 Felstead	*7.60*	+0.57	+0.44	+0.56	−1.62	−0.36	+0.01
28 Oaklands I	*7.45*	+0.44	+0.62	+3.01	−1.06	+1.16	−0.58
29 Selby II	*8.94*	+0.73	−0.39	−0.02	−1.13	+0.14	+1.38
Mean	*8.00*	*+0.58*	*+0.22*	*+1.18*	*−1.27*	*+0.31*	*+0.27*
FENS							
30 Ely	*14.62*	−0.53	−1.48	+1.71	+1.57	−1.16	+1.99
31 Peterboro' II	*6.26*	−1.26	+0.45	+1.31	−0.67	−0.26	+0.63
32 Wissington II	*5.20*	+1.21	+3.40	−0.02	−1.52	+0.19	−0.25
Mean	*8.69*	*−0.19*	*+0.79*	*+1.00*	*−0.21*	*−0.41*	*+0.79*
Mean	*8.28*	*+0.76*	*+0.39*	*+0.71*	*−0.67*	*−0.28*	*+0.05*

Station	*Mean yield*	Linear Response (response to the double dressing)			St. error	Curvature (excess of extra response to second dressing over response to first dressing)			St. error
		N	P	K		N	P	K	
				TOPS : tons per acre					
COARSE SANDS									
1 Allscott I	*12.01*	+2.68*	−0.35	−0.94	±0.919	+0.28	−1.15	−0.21	±1.59
2 Allscott II ..	*12.10*	+2.15*	+0.99	−0.60	±0.882	−1.48	+0.60	+0.68	±1.53
3 Cantley I ..	*6.95*	+3.19**	+0.36	−0.51	±0.326	+0.01	+0.26	−0.44	±0.565
4 Cantley II ..	*6.49*	+3.31**	+0.14	−0.49*	±0.224	+0.57	+0.13	+0.06	±0.387
5 Colwick ..	*11.18*	+4.09**	−0.85	+4.24**	±0.759	−2.66	+0.62	−1.75	±1.31
6 King's Lynn I	*6.70*	+3.40**	+0.69	−0.80*	±0.326	+0.56	−0.36	−0.10	±0.565
7 King's Lynn II	*5.54*	+1.40**	−0.19	−0.04	±0.316	+0.57	+0.77	−0.07	±0.547
8 Newark I ..	*9.44*	+5.00**	+1.09**	+2.14**	±0.320	—0.48	+0.20	−1.48*	±0.554
9 Selby I ..	*8.77*	+6.71**	−0.83	+0.29	±0.547	−1.04	−1.75	+0.50	±0.947
10 Wissington I ..	*11.16*	+2.99*	+0.04	−0.72	±1.09	+1.35	−0.76	−0.95	±1.89
11 Wissington III	*7.20*	+2.31**	−0.03	−0.71	±0.467	+0.02	−0.08	−0.66	±0.808
Mean	*8.87*	*+3.38*	*+0.10*	*+0.17*		*−0.21*	*−0.14*	*−0.40*	
FINE SANDS									
12 Bardney I ..	*14.60*	+3.99**	−0.76	+0.10	±0.641	+1.96	+0.95	+0.18	±1.11
13 Bardney II ..	*10.45*	+6.50**	−0.16	−0.25	±0.599	+1.78	−0.49	+0.76	±1.04
14 Brigg I ..	*13.33*	+3.89**	+0.72	+0.68	±0.646	−1.35	+1.66	−0.26	±1.12
15 Brigg II ..	*8.88*	+3.46**	+0.09	+0.96	±0.613	−0.05	−0.23	−0.32	±1.06
16 Bury II ..	*5.29*	+0.36	+0.41	+0.28	±0.218	−0.28	−0.02	+0.01	±0.377
17 Cupar I ..	*10.14*	+3.15**	−0.74	+0.39	±0.910	+0.62	+0.83	+1.55	±1.58
19 Kidderminster	*12.87*	+1.52	−0.82	−2.21*	±0.773	−1.89	−3.47*	−2.12	±1.34
20 Poppleton ..	*5.29*	+3.15**	+0.06	−0.16	±0.424	+0.75	+1.12	+0.72	±0.734
Mean	*10.11*	*+3.25*	*−0.15*	*0.00*		*+0.19*	*+0.04*	*+0.06*	
LIGHT LOAMS									
22 Cupar II ..	*8.23*	+1.57	+0.56	+0.72	±0.929	−1.81	−1.08	+0.74	±1.61
24 Oaklands II ..	*5.54*	+0.83**	−0.26	+0.32	±0.196	−0.68	−0.22	−1.06**	±0.340
25 Spalding I ..	*4.32*	+1.27**	+0.21	+0.12	±0.197	−0.69	−0.21	−0.27	±0.341
Mean	*6.03*	*+1.22*	*+0.17*	*+0.39*		*−1.06*	*−0.50*	*−0.20*	
CLAY LOAMS									
27 Felstead ..	*7.01*	+2.03*	+0.57	−0.36	±0.693	−1.13	−1.60	−0.29	±1.20
28 Oaklands I ..	*8.55*	+3.31**	+1.08	+1.12	±0.580	−2.01	+1.66	−0.18	±1.00
29 Selby II ..	*12.94*	+2.02	−0.02	+0.04	±1.16	+0.30	+0.12	+1.02	±2.01
Mean	*9.50*	*+2.45*	*+0.54*	*+0.27*		*−0.95*	*+0.06*	*+0.18*	
FENS									
30 Ely	*20.71*	+0.52	+0.09	−0.63	±0.556	+1.28	+1.64	−0.04	±0.963
31 Peterboro' II ..	*10.86*	−0.23	+0.66	−0.08	±0.546	−0.90	−1.25	+0.27	±0.946
32 Wissington II ..	*11.47*	+2.34*	+6.17**	+0.57	±1.01	−2.27	+1.20	+0.08	±1.75
Mean	*14.35*	*+0.88*	*+2.31*	*−0.05*		*−0.63*	*+0.53*	*+0.10*	
Mean	*9.57*	*+2.75*	*+0.32*	*+0.12*		*−0.31*	*−0.03*	*−0.13*	

Station	*Mean*	Linear Response (response to the double dressing)			St. error	Curvature (excess of extra response to second dressing over response to first dressing)			St. error
		N	P	K		N	P	K	
SUGAR PERCENTAGE									
COARSE SANDS									
1 Allscott I ..	*16.97*	−0.29	−0.17	+0.27	±0.187	−0.29	−0.47	−0.17	±0.323
2 Allscott II ..	*16.51*	+0.31	+0.07	+0.60*	±0.218	−0.41	+0.01	−0.14	±0.377
3 Cantley I ..	*14.54*	−0.63**	+0.11	+0.78**	±0.173	−0.14	+0.02	−0.31	±0.300
4 Cantley II ..	*15.52*	−0.41**	−0.04	+0.40**	±0.134	−0.08	−0.04	−0.31	±0.232
5 Colwick ..	*16.24*	−0.25*	−0.04	+0.75**	±0.086	−0.01	−0.34*	−0.07	±0.149
6 King's Lynn I ..	*15.61*	−0.77**	+0.29	+0.44*	±0.153	+0.09	−0.33	+0.18	±0.265
7 King's Lynn II	*15.48*	−1.35**	−0.42	+0.06	±0.205	+0.21	−0.48	+0.18	±0.355
8 Newark I ..	*17.46*	−0.25	−0.10	+0.63**	±0.203	−0.79*	+0.02	−0.73	±0.351
9 Selby I	*16.28*	+0.37	−0.37	−0.07	±0.255	−0.17	−0.23	−0.41	±0.443
10 Wissington I ..	*16.55*	−0.35*	+0.02	+0.45*	±0.156	−0.37	+0.14	+0.59*	±0.270
11 Wissington III ..	*16.18*	−0.69**	−0.22	+0.77**	±0.139	+0.13	−0.14	−0.23	±0.241
Mean	*16.12*	*−0.39*	*−0.08*	*+0.46*		*−0.17*	*−0.17*	*−0.13*	
FINE SANDS									
12 Bardney I ..	*16.65*	−0.39**	+0.03	+0.35**	±0.102	−0.11	+0.25	−0.11	±0.177
13 Bardney II ..	*16.99*	−0.18	+0.22	+0.01	±0.180	+0.38	+0.68*	+0.05	±0.312
14 Brigg I	*16.72*	−0.22	0.00	+0.14	±0.175	−0.70*	−0.40	−0.16	±0.303
15 Brigg II ..	*17.03*	−0.14	−0.13	+0.70**	±0.137	−0.14	−0.29	−0.08	±0.237
16 Bury II ..	*16.50*	0.00	+0.49	+0.93**	±0.279	−0.46	−0.25	+0.05	±0.483
17 Cupar I ..	*16.17*	−0.78*	+0.23	−0.53	±0.273	−1.02*	+0.93	−0.21	±0.474
18 Ipswich I ..	*14.45*	−0.72**	−0.40*	+0.81**	±0.145	0.00	+0.12	+0.15	±0.251
19 Kidderminster	*16.84*	+0.09	+0.30	−0.02	±0.341	+0.21	+0.36	+0.54	±0.590
20 Poppleton ..	*18.29*	−0.27	−0.19	−0.07	±0.154	+0.19	−0.29	+0.25	±0.267
Mean	*16.63*	*−0.29*	*+0.06*	*+0.26*		*−0.18*	*+0.12*	*+0.05*	
LIGHT LOAMS									
22 Cupar II ..	*16.90*	+0.31	−0.06	+0.26	±0.181	+0.15	−0.12	+0.24	±0.314
23 Ipswich II ..	*15.24*	−0.45**	+0.06	+0.07	±0.151	+0.17	−0.04	−0.37	±0.262
24 Oaklands II ..	*14.30*	−0.73*	+0.15	+0.14	±0.257	+0.33	+0.03	+0.36	±0.445
25 Spalding I ..	*16.73*	−0.89**	−0.36	+0.74**	±0.170	−0.13	+0.32	+0.56	±0.295
Mean	*15.79*	*−0.44*	*−0.05*	*+0.30*		*+0.13*	*+0.05*	*+0.20*	
HEAVY LOAM									
26 Peterboro' I ..	*16.97*	−0.74**	+0.55**	+0.24	±0.156	−0.20	−0.29	−0.26	±0.270
CLAY LOAM									
27 Felstead ..	*15.91*	−0.96**	−0.14	+0.22	±0.185	−0.68	+0.46	+0.46	±0.321
28 Oaklands I ..	*16.72*	−0.79**	−0.31*	+0.51**	±0.112	+0.19	−0.29	−0.41	±0.194
29 Selby II ..	*15.18*	−0.32	−0.18	+0.07	±0.210	+0.26	+0.02	+0.41	±0.363
Mean	*15.94*	*−0.69*	*−0.21*	*+0.27*		*−0.08*	*+0.06*	*+0.15*	
FENS									
30 Ely	*15.67*	−0.07	−0.28	+0.14	±0.161	−0.13	+0.03	−0.10	±0.279
31 Peterboro' II ..	*17.80*	−0.52**	−0.02	+0.40**	±0.129	+0.12	+0.54*	−0.18	±0.223
32 Wissington II ..	*12.81*	−0.18	+0.34	+0.18	±0.268	0.00	+0.54	−0.48	±0.464
Mean	*15.43*	*−0.26*	*+0.01*	*+0.24*		*0.00*	*+0.37*	*−0.25*	
Mean	*16.17*	*−0.40*	*−0.08*	*+0.33*		*−0.11*	*+0.01*	*−0.02*	

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Station	*Mean*	Linear Response (response to the double dressing)			St. error	Curvature (excess of extra response to second dressing over response to first dressing)			St. error
		N	P	K		N	P	K	
		PLANT NUMBER: thousands per acre							
COARSE SANDS									
1 Allscott I ..	*26.8*	−0.5	+0.3	+0.5	±0.745	−1.2	+1.2	−0.2	±1.29
2 Allscott II ..	*25.7*	+1.0	+1.1	−0.4	±0.952	−1.6	−0.3	−2.1	±1.65
3 Cantley I ..	*26.1*	−0.2	+1.5	+2.6	±1.23	−2.8	−2.5	−1.3	±2.12
4 Cantley II ..	*41.4*	+0.3	−0.1	+1.2	±1.17	+0.1	−2.0	−0.5	±2.03
5 Colwick ..	*25.0*	−1.3	−0.8	+2.3*	±0.886	0.0	+2.0	−2.1	±1.54
6 King's Lynn I ..	*29.3*	0.0	0.0	−0.6	±0.981	+0.8	−1.0	+0.9	±1.70
7 King's Lynn II	*26.6*	−1.2	−0.3	−1.3	±0.915	−0.5	+1.0	+2.5	±1.58
8 Newark I ..	*25.6*	+0.1	+0.5	+2.1**	±0.415	+0.5	−0.5	−1.7*	±0.719
9 Selby I	*30.7*	−0.9	+0.7	+0.3	±0.764	−0.3	+0.4	+1.9	±1.32
10 Wissington I ..	*24.2*	−0.9	+0.7	−0.6	±1.04	0.0	−0.1	+1.4	±1.80
11 Wissington II ..	*36.8*	−0.8	+1.1	−0.2	±0.768	+0.3	0.0	−1.2	±1.33
Mean	*28.9*	*−0.4*	*+0.4*	*+0.5*		*−0.4*	*−0.2*	*−0.2*	
FINE SANDS									
12 Bardney I ..	*29.8*	−1.4*	+0.3	−0.8	±0.599	+0.4	−2.0	+1.3	±1.04
13 Bardney II ..	*29.9*	+1.4	−1.9	−0.8	±0.948	−1.0	+1.3	−0.6	±1.64
14 Brigg I	*25.2*	+0.2	−0.1	+0.2	±0.792	−2.0	−0.1	−1.1	±1.37
15 Brigg II ..	*25.5*	+0.8	+0.1	−1.9	±0.915	+1.3	+0.9	+0.8	±1.58
16 Bury II ..	*17.4*	−1.3	−0.2	+1.3	±0.849	−3.7*	+2.8	−0.8	±1.47
17 Cupar I ..	*19.7*	+1.7*	−0.3	−0.5	±0.726	−0.6	−1.1	+1.5	±1.26
18 Ipswich I ..	*24.5*	−1.1	−0.3	0.0	±1.03	−0.1	−4.6*	−2.8	±1.78
19 Kidderminster	*26.6*	−1.5	+0.2	−0.4	±0.882	0.0	−1.1	−1.9	±1.53
20 Poppleton ..	*22.7*	+0.6	+0.3	+0.6	±0.806	+2.4	+0.9	+0.7	±1.40
Mean	*24.6*	*−0.1*	*−0.2*	*−0.3*		*−0.4*	*−0.3*	*−0.3*	
LIGHT LOAMS									
22 Cupar II ..	*29.8*	+1.4	−0.1	+2.1	±1.16	+1.2	−2.0	+0.4	±2.01
23 Ipswich II ..	*28.6*	+0.7	+0.4	−0.5	±0.797	+1.1	−0.9	+0.2	±1.38
24 Oaklands II ..	*24.5*	+0.7	+0.4	−0.8	±0.688	−1.8	+1.1	−1.2	±1.19
25 Spalding ..	*25.1*	−0.4	+0.1	−0.3	±0.872	−1.1	−0.5	+2.2	±1.51
Mean	*27.0*	*+0.6*	*+0.2*	*+0.1*		*−0.2*	*−0.6*	*+0.4*	
HEAVY LOAM									
26 Peterboro' I ..	*22.2*	+0.4	0.0	−0.6	±0.976	+3.3	−1.6	−0.3	±1.69
CLAY LOAMS									
27 Felstead ..	*18.4*	+1.1	+0.3	+1.2	±1.11	+1.3	+0.6	+0.4	±1.93
28 Oaklands I ..	*17.2*	−0.8	−0.5	+2.6*	±0.999	−0.3	+1.6	−3.4	±1.73
29 Selby II ..	*20.9*	+1.7	−0.3	+0.1	±1.21	−1.3	−0.4	+1.2	±2.10
Mean	*18.8*	*+0.7*	*−0.2*	*+1.3*		*−0.1*	*+0.6*	*−0.6*	
FENS									
30 Ely	*32.4*	−0.4	−0.5	+0.4	±0.606	−0.2	−0.5	−1.0	±1.05
31 Peterboro' II ..	*30.0*	−5.6*	+0.2	+5.0*	±2.03	+0.3	−5.9	+1.2	±3.51
32 Wissington II	*20.9*	+0.8	+0.9	+1.0	±0.589	−2.3*	−0.1	+2.1	±1.02
Mean	*27.8*	*−1.7*	*+0.2*	*+2.1*		*−0.7*	*−2.2*	*+0.8*	
Mean	*26.1*	*−0.2*	*+0.1*	*+0.4*		*−0.3*	*−0.4*	*−0.1*	

Station	*Mean*	Linear Response (response to the double dressing)			St. error	Curvature (excess of extra response to second dressing over response to first dressing)			St. error
		N	P	K		N	P	K	
PERCENTAGE PURITY									
COARSE SANDS									
5 Colwick . .	*86.6*	−0.7	−0.5	+0.3	±0.329	−0.4	+0.8	−0.6	±0.570
6 King's Lynn I . .	*89.9*	−1.1	+0.4	+0.3	±0.570	−0.7	−0.3	+0.2	±0.988
7 King's Lynn II . .	*89.4*	−1.3*	−0.4	−1.7**	±0.465	+0.4	−0.3	+0.2	±0.805
8 Newark I . .	*90.3*	+0.2	−0.2	−0.1	±0.481	−0.1	−0.2	−0.5	±0.833
9 Selby I	*86.8*	+1.0	−2.5**	+1.2	±0.811	−0.8	−2.5	−1.2	±1.40
10 Wissington I . .	*89.6*	+0.2	−0.4	+0.3	±0.324	+0.4	+0.6	−0.7	±0.562
11 Wissington III . .	*89.8*	−0.3	−0.1	−0.2	±0.297	−0.5	−0.1	−0.9	±0.513
Mean	*88.9*	*−0.3*	*−0.5*	*0.0*		*−0.2*	*−0.3*	*−0.5*	
FINE SANDS									
12 Bardney I . .	*87.3*	−0.2	−0.8	−0.3	±0.476	−1.6	−1.0	+1.4	±0.825
14 Brigg I	*90.2*	−0.2	+0.2	−0.1	±0.314	−0.3	+0.4	+1.2*	±0.545
15 Brigg II . .	*90.1*	+0.2	−0.3	+0.4	±0.365	0.0	+0.1	0.0	±0.633
16 Bury II . .	*85.5*	+2.0	−1.4	+1.1	±1.20	−0.9	−1.5	−5.3*	±2.08
17 Cupar I	*87.1*	0.0	−0.2	0.0	±0.159	0.0	+0.1	0.0	±0.275
20 Poppleton . .	*90.6*	0.0	−0.1	0.0	±0.140	+0.6*	+0.2	−0.3	±0.243
Mean	*88.5*	*+0.3*	*−0.4*	*+0.2*		*−0.4*	*−0.3*	*−0.5*	
LIGHT LOAMS									
22 Cupar II . .	*88.2*	+0.2	+0.3	0.0	±0.412	−0.2	−0.5	+1.0	±0.714
HEAVY LOAM									
26 Peterboro' I	*82.9*	−1.4	+0.7	+3.0**	±0.867	0.0	−0.8	+0.8	±1.50
CLAY LOAMS									
27 Felstead . .	*86.8*	−0.2	+0.1	+0.4*	±0.169	−0.4	−0.1	+0.4	±0.293
29 Selby II . .	*87.2*	−0.5	−0.4	+0.3	±0.448	+0.2	+0.5	+0.8	±0.776
Mean	*85.6*	*−0.4*	*−0.2*	*+0.4*		*−0.1*	*+0.2*	*+0.6*	
FENS									
30 Ely	*88.5*	*−0.5*	*−0.1*	*−0.1*	±0.504	−0.2	−0.4	−0.1	±0.873
31 Peterboro' II	*80.7*	−0.9	+0.3	+1.2	±0.773	+0.6	+0.9	−0.5	±1.34
32 Wissington II	*83.2*	−0.1	+0.6	−0.4	±0.379	+0.5	−0.4	+0.3	±0.656
Mean	*84.1*	*−0.5*	*+0.3*	*+0.2*		*+0.3*	*0.0*	*−0.1*	
Mean	*87.5*	*−0.2*	*−0.2*	*+0.3*		*−0.2*	*−0.2*	*−0.2*	

Interactions

Station	Interaction of linear responses (one half of the extra response to one fertilizer through the addition of a second)			St. error	Interaction of linear responses (one half of the extra response to one fertilizer through the addition of a second)		
	N×P	**N×K**	**P×K**		**N×P**	**N×K**	**P×K**
	TOTAL SUGAR : cwt. per acre				ROOTS (washed) : tons per acre		
COARSE SANDS							
1 Allscott I (*a*)	−1.5	+0.1	−0.9	±1.20	−0.46	−0.33	−0.41
2 Allscott II	−0.1	−0.1	−6.2**	±1.31	−0.20	−0.38	−1.76
3 Cantley I (*a*)	+1.7	+2.1	0.0	±0.802	+0.20	+0.50	−0.25
4 Cantley II	+1.6	+0.6	+0.2	±0.884	+0.56	+0.08	−0.02
5 Colwick	−1.0	+1.8*	−0.3	±0.785	−0.36	+0.65	−0.10
6 King's Lynn I	−1.0	+2.4*	+0.9	±0.872	−0.28	+0.79	+0.29
7 King's Lynn II (*a*)	−0.8	−0.7	−2.1*	±0.895	+0.29	−0.23	−0.22
8 Newark I	−1.9	+1.3	+3.3*	±1.14	−0.56	+0.37	+0.80
9 Selby I	−0.1	+1.5	0.0	±1.73	+0.15	+0.38	−0.07
10 Wissington I (*a*)	+2.2	+2.3	−0.4	±1.64	+0.39	+0.69	−0.46
11 Wissington III (*a*)	−4.7	−1.3	−3.4	±2.25	−0.78	+0.36	−0.36
Mean	*−0.5*	*+0.9*	*−0.8*		*−0.10*	*+0.26*	*−0.23*
FINE SANDS							
12 Bardney I	−0.3	+1.5	+1.8	±1.39	−0.34	+0.58	+0.64
13 Bardney II (*a*)	+3.6	−0.9	+3.9	±2.09	+1.91	−0.53	+0.41
14 Brigg I (*a*)	−0.8	+2.3	+0.1	±2.18	−0.51	+0.70	−0.17
15 Brigg II	+0.8	−1.4	−1.1	±2.37	+0.19	−0.56	−0.29
16 Bury II	+0.4	+0.1	−0.8	±0.970	+0.21	+0.15	−0.15
17 Cupar I	+0.5	+0.3	−0.6	±2.22	+0.24	−0.12	−0.21
18 Ipswich I (*a*)	+4.3	−1.4	+2.1	±2.05	+0.94	−0.33	+1.23
19 Kidderminster	−3.7	+7.4**	+3.8	±2.12	−0.97	+2.01	+1.14
20 Poppleton	+2.4	−2.3	−1.0	±2.27	+0.63	−0.67	−0.22
Mean	*+0.8*	*+0.6*	*+0.9*		*+0.26*	*+0.14*	*+0.26*
LIGHT LOAMS							
21 Bury I (*a*)	−0.8	−0.5	−1.0	±0.818	—	—	—
22 Cupar II	−0.8	−0.8	+0.9	±1.78	−0.20	−0.19	+0.29
23 Ipswich II (*a*)	+0.6	+1.0	+2.2*	±1.00	+0.15	+0.39	+1.11
24 Oaklands II	+0.5	−0.5	+1.4	±0.664	+0.10	−0.12	+0.45
25 Spalding I (*a*)	−1.1	+0.7	+1.3	±1.02	−0.31	+0.15	+0.39
Mean	*−0.3*	*0.0*	*+1.0*		*−0.06*	*+0.06*	*+0.56*
HEAVY LOAM							
26 Peterboro' I (*a*)	+3.6*	+0.4	+0.6	±1.37	+0.95	+0.51	−0.25
CLAY LOAMS							
27 Felstead	−0.3	−0.8	−0.3	±1.12	−0.11	−0.22	−0.08
28 Oaklands I	−0.9	+2.8	+1.4	±2.02	−0.13	+0.93	+0.40
29 Selby I (*a*)	+0.8	−0.5	+1.3	±1.60	+0.21	−0.26	+1.28
Mean	*−0.1*	*+0.5*	*+0.8*		*−0.01*	*+0.15*	*+0.53*
FENS							
30 Ely (*a*)	+2.2	−4.3	+1.6	±2.55	+1.00	−0.38	+0.62
31 Peterboro' II	−4.7	−2.9	+0.1	±2.96	−1.15	−0.68	+0.02
32 Wissington II (*a*)	−2.8	−1.3	−0.1	±1.62	−1.66	−0.89	−0.49
Mean	*−1.8*	*−2.8*	*+0.5*		*−0.60*	*−0.65*	*+0.05*
Mean	*−0.1*	*+0.3*	*+0.3*		*0.00*	*+0.11*	*+0.11*

(*a*) Total sugar adjusted for plant number.

Station	Interaction of ' linear responses (one half of the extra response to one fertilizer through the addition of a second)			St. error	Interaction of linear responses (one half of the extra response to one fertilizer through the addition of a second)			St. error
	N×P	N×K	P×K		N×P	N×K	P×K	
	TOPS : tons per acre				SUGAR PERCENTAGE			
COARSE SANDS								
1 Allscott I . .	+0.37	+0.38	+1.77	±1.13	+0.04	+0.26	−0.18	±0.229
2 Allscott II . .	−0.34	+0.60	+0.50	±1.08	+0.26	+0.51	−0.22	±0.267
3 Cantley I . .	+0.59	−0.19	−0.35	±0.399	+0.42	+0.35	−0.12	±0.212
4 Cantley II . .	+0.73*	−0.60*	−0.14	±0.274	−0.05	+0.27	+0.22	±0.164
5 Colwick . .	−1.72	+0.82	+1.07	±0.930	+0.14	−0.22	−0.10	±0.106
6 King's Lynn I	+0.70	−0.23	−0.45	±0.400	−0.18	−0.09	+0.02	±0.188
7 King's Lynn II	+0.83*	−0.15	+0.30	±0.387	−0.28	−0.45	−0.03	±0.251
8 Newark I . .	+0.17	+0.81	+0.40	±0.391	+0.08	+0.04	+0.39	±0.248
9 Selby I . .	+0.37	+0.20	−0.86	±0.670	−0.22	+0.09	+0.12	±0.313
10 Wissington I . .	−1.41	+1.23	−0.72	±1.34	+0.10	−0.03	+0.30	±0.191
11 Wissington III	−0.21	−0.10	−0.35	±0.572	−0.30	−0.14	−0.46*	±0.170
Mean	*+0.01*	*+0.25*	*+0.11*		*0.00*	*+0.05*	*−0.01*	
FINE SANDS								
12 Bardney I . .	−0.51	+0.39	+1.46	±0.785	+0.30*	−0.15	−0.15	±0.125
13 Bardney II . .	+1.47	−0.68	+0.61	±0.733	+0.04	+0.18	+0.06	±0.221
14 Brigg I . .	+0.32	+0.46	−0.05	±0.791	−0.36	+0.20	+0.16	±0.214
15 Brigg II . .	−0.21	−0.25	+0.15	±0.751	+0.12	+0.14	−0.02	±0.167
16 Bury II . .	+0.32	+0.16	+0.04	±0.267	−0.26	−0.38	−0.34	±0.341
17 Cupar I . .	+2.52*	+1.57	+1.03	±1.11	−0.06	+0.39	+0.08	±0.335
18 Ipswich I . .	—	—	—	—	−0.12	−0.08	+0.06	±0.177
19 Kidderminster	−1.18	+3.51**	+0.47	±0.947	−0.18	+0.20	−0.06	±0.417
20 Poppleton . .	+0.58	−0.78	+0.13	±0.519	+0.16	+0.16	−0.12	±0.189
Mean	*+0.41*	*+0.55*	*+0.48*		*−0.04*	*+0.07*	*−0.04*	
LIGHT LOAMS								
22 Cupar II . .	+0.61	+0.77	+0.63	±1.14	−0.02	−0.12	−0.04	±0.222
23 Ipswich II . .	—	—	—	—	+0.14	+0.15	−0.03	±0.185
24 Oaklands II . .	+0.03	−0.36	+0.26	±0.240	+0.27	−0.21	+0.16	±0.315
25 Spalding I . .	−0.37	+0.16	+0.35	±0.241	−0.50*	−0.14	+0.38	±0.208
Mean	*+0.09*	*+0.19*	*+0.41*		*−0.03*	*−0.08*	*+0.12*	
HEAVY LOAM								
26 Peterboro' I . .	—	—	—	—	+0.42*	+0.06	−0.15	±0.191
CLAY LOAMS								
27 Felstead . .	+0.27	−0.43	+0.60	±0.849	+0.12	−0.03	−0.09	±0.227
28 Oaklands I . .	+0.02	+1.32	−0.14	±0.710	−0.30*	−0.08	+0.06	±0.137
29 Selby II . .	+0.06	+0.90	+0.39	±1.42	+0.10	+0.03	−0.44	±0.257
Mean	*+0.12*	*+0.60*	*+0.28*		*−0.03*	*−0.03*	*−0.16*	
FENS								
30 Ely	+0.02	+0.35	−0.36	±0.681	−0.02	−0.05	+0.03	±0.197
31 Peterboro' II . .	+0.76	+0.88	+0.56	±0.669	−0.44*	−0.28	−0.10	±0.158
32 Wissington II . .	−3.29*	−2.57	−1.27	±1.24	−0.32	−0.21	−0.21	±0.328
Mean	*−0.84*	*−0.45*	*−0.36*		*−0.26*	*−0.18*	*−0.09*	
Mean	*+0.05*	*+0.29*	*+0.22*		*−0.03*	*+0.01*	*−0.03*	

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Station	Interaction of linear responses (one half of the extra response to one fertilizer through the addition of a second)			St. error	Interaction of linear responses (one half of the extra response to one fertilizer through the addition of a second)			St. error
	N×P	N×K	P×K		N×P	N×K	P×K	
	PLANT NUMBER: thousands per acre				PERCENTAGE PURITY			
COARSE SANDS								
1 Allscott I	+0.1	−0.6	−1.0	±0.912	—	—	—	—
2 Allscott II	−2.2	−0.7	−1.8	±1.17	—	—	—	—
3 Cantley I	−1.6	−0.7	−1.4	±1.50	—	—	—	—
4 Cantley II	+0.5	−2.0	+0.2	±1.44	—	—	—	—
5 Colwick	+0.3	−0.4	+1.3	±1.09	0.0	+0.5	+0.4	±0.403
6 King's Lynn I	−1.7	−0.4	+1.1	±1.20	−0.7	+0.4	+0.5	±0.699
7 King's Lynn II	+1.6	−0.6	+1.8	±1.12	−0.2	−1.3*	−0.7	±0.569
8 Newark I	−0.1	−0.7	−0.1	±0.508	−0.8	−0.2	−0.6	±0.589
9 Selby I	−0.3	0.0	+0.5	±0.935	−1.2	+1.0	−0.3	±0.993
10 Wissington I	−0.8	−0.2	−0.5	±1.28	+0.2	−0.8	+0.4	±0.397
11 Wissington III	+1.1	+1.4	+1.1	±0.941	−0.1	−0.3	−0.8*	±0.363
Mean	*−0.3*	*−0.4*	*+0.1*		*−0.4*	*−0.1*	*−0.2*	
FINE SANDS								
12 Bardney I	−0.6	+0.8	+0.5	±0.733	−0.2	+0.1	−1.1	±0.583
13 Bardney II	+2.2	−0.4	−1.7	±1.16	—	—	—	—
14 Brigg I	−1.1	+0.3	−0.1	±0.970	0.0	−0.1	+0.4	±0.385
15 Brigg II	−0.8	+0.5	−1.3	±1.12	+0.1	+0.2	−0.2	±0.447
16 Bury II	+1.2	−0.9	−0.1	±1.04	+0.4	+0.3	+3.4*	±1.47
17 Cupar I	−0.2	0.0	−0.3	±0.889	+0.2	0.0	0.0	±0.195
18 Ipswich I	−1.5	+0.2	+1.3	±1.26	—	—	—	—
19 Kidderminster	−1.5	+1.4	+1.8	±1.08	—	—	—	—
20 Poppleton	0.0	+0.4	+0.1	±0.987	−0.1	−0.2	−0.1	±0.172
Mean	*−0.3*	*+0.3*	*0.0*		*+0.1*	*0.0*	*+0.4*	
LIGHT LOAMS								
22 Cupar II	−2.9	−0.1	−1.3	±1.42	−1.0	−0.3	+1.0	±0.505
23 Ipswich II	+0.2	+0.6	+1.5	±0.976	—	—	—	—
24 Oaklands II	+0.3	−0.5	+1.1	±0.843	—	—	—	—
25 Spalding I	−0.3	−0.3	+0.4	±1.07	—	—	—	—
Mean	*−0.7*	*−0.1*	*+0.4*		*−1.0*	*−0.3*	*+1.0*	
HEAVY LOAM								
26 Peterboro' I	+0.4	+1.4	−1.6	±1.20	+0.9	−1.1	−1.3	±1.06
CLAY LOAMS								
27 Felstead	0.0	−1.1	−0.3	±1.36	−0.1	+0.2	−0.1	±0.207
28 Oaklands I	−0.6	+0.9	−1.1	±1.22	—	—	—	—
29 Selby II	+0.1	−0.2	+2.6	±1.48	+0.5	+0.8	−0.5	±0.549
Mean	*−0.2*	*−0.1*	*+0.4*		*+0.2*	*+0.5*	*−0.3*	
FENS								
30 Ely	−0.3	−1.0	−0.1	±0.742	−0.4	−0.3	+0.8	±0.617
31 Peterboro' II	−2.6	−0.6	+1.5	±2.48	−1.6	−1.0	0.0	±0.947
32 Wissington II	−1.2	−0.8	−0.9	±0.722	−0.4	−0.7	−0.5	±0.464
Mean	*−1.4*	*−0.8*	*+0.2*		*−0.8*	*−0.7*	*+0.1*	
Mean	*−0.4*	*−0.1*	+0.1		*−0.2*	*−0.1*	*0.0*	

Conclusions

Owing to the exceptional drought in spring, the yields of roots and sugar and the sugar percentages in these experiments were substantially lower than in any previous year, the mean yield of total sugar being 26.7 cwt. per acre against an average of 38.9 cwt. for the period 1933-7. Plant numbers also were variable and rather low. Tops recovered somewhat in September and October, and the mean yield, 9.57 tons per acre, is about the average for the preceding five years.

Effects of sulphate of ammonia

The average response in total sugar to the double dressing of sulphate of ammonia was 1.9 cwt. per acre. This is the smallest response in any year except 1933. There were as usual significant differences in the response from centre to centre ; in particular yields were significantly depressed at King's Lynn II and Peterborough II. The additional increase to the second dressing was on the average significantly smaller than the increase to the first dressing.

All except six of the twenty-eight centres where tops were weighed showed significant increases to sulphate of ammonia. The mean response to the double dressing was 2.8 tons per acre. This figure has varied little in the past five seasons.

The responses varied significantly from centre to centre. At King's Lynn II, where total sugar was significantly depressed by sulphate of ammonia, tops nevertheless shared a significant increase. There was little indication of any falling-off in effectiveness at the higher level of application.

Sugar percentage was decreased at all except five centres, the average decrease being 0.40. The effects on roots were in general similar to those on total sugar. The average effects on plant numbers were small, the only exception being a marked depression on the fen soil at Peterboro' II.

Effects of superphosphate

The average response in sugar to the 6 cwt. dressing was 1.1 cwt. per acre. There was a striking depression of 7.0 cwt. per acre on the good crop at Ely. There was some indication of a falling-off in response to the second dressing at centres which responded well to superphosphate, though this was not significant. The effects on tops were small at most centres, though there was a striking increase at Wissington II and a significant increase at Newark I. Superphosphate had little effect on sugar percentage, percentage purity or plant number.

Effects of muriate of potash

The average increase in sugar to the double dressing was 2.9 cwt. per acre, this being practically the same as last year. Responses of over 10 cwt. per acre were obtained at Colwick, Newark I and Oaklands I, the last centre being in the clay loam soil group on which muriate of potash has not been very effective in past years. There was no indication of a decrease in responsiveness with the double dressing, except at the three centres which showed very high responses.

The average effect on tops was small and not significant. There were, however, significant increases at Colwick and Newark I and significant decreases at Cantley I, King's Lynn I and Kidderminster.

Sugar percentages were increased significantly at fifteen centres, the average increase over all centres being 0.33. Plant numbers were increased significantly at four centres, but the average effect was small.

Interactions

The positive interaction between sulphate of ammonia and muriate of potash was not so marked as in previous years. The average interaction over all centres, though positive, was not significant.

Bolters

Counts of bolters were made at Bardney I, the mean percentage of bolted plants being 3.0· All three fertilizers produced significant increases in the percentage of bolters.

EXPERIMENTS AT OUTSIDE CENTRES

Barley. E. M. Howard, Esq., Nocton, Lincoln, 1938

1st Year Residual Effects after Fertilizer Experiment on Sugar Beet (Factory Series)

3 randomized blocks of 9 plots each. Plots : 1/40 acre.

Treatments : 3×3×3 factorial design.

See 1937 Report, page 175, *et seq.*, Bardney I experiment, No. 15. Treatments applied to 1937 sugar beet experiment :—

Sulphate of ammonia : None, 0.4 cwt., 0.8 cwt. N per acre.

Superphosphate : None, 0.5 cwt., 1.0 cwt. P_2O_5 per acre.

Muriate of potash : None, 0.6 cwt., 1.2 cwt. K_2O per acre.

Basal Manuring : Nil.

Soil : Coarse sandy loam. Variety : Spratt Archer. Seed sown : March 4 and 5. Harvested : Aug. 17.

Standard Error per Plot : Grain : 2.07 cwt. per acre or 10.2%.

Residual main effects—Interactions of sulphate of ammonia with superphosphate and muriate of potash

Sulphate of ammonia	Superphosphate (cwt. P_2O_5)			Muriate of potash (cwt. K_2O)			*Mean*	*Increase*
	0.0	0.5	1.0	0.0	0.6	1.2		
GRAIN : cwt. per acre (±1.19. *Means:* ±*0.690.* *Increases:* ±*0.976*)								
0.0 cwt. N	19.61	20.26	19.86	19.38	19.46	20.88	*19.91*	
0.4 cwt. N	19.96	20.98	20.87	22.96	19.17	19.68	*20.60*	*+0.69*
0.8 cwt. N	19.98	20.07	20.77	20.46	19.38	20.98	*20.27*	*−0.33*
Mean ..	*19.85*	*20.44*	*20.50*	*20.93*	*19.34*	*20.51*	*20.26*	
Increase ..		*+0.59*	*+0.06*		*−1.59*	*+1.17*		
STRAW : cwt. per acre								
0.0 cwt. N	21.97	21.43	20.37	20.37	21.03	22.37	*21.26*	
0.4 cwt. N	19.47	20.47	21.03	22.07	19.77	19.13	*20.32*	*−0.94*
0.8 cwt. N	20.97	21.00	20.90	21.33	20.23	21.30	*20.95*	*+0.63*
Mean ..	*20.80*	*20.97*	*20.77*	*21.26*	*20.34*	*20.93*	*20.84*	
Increase ..		*+0.17*	*−0.20*		*−0.92*	*+0.59*		

Residual interaction of muriate of potash with superphosphate

Muriate of potash	GRAIN : cwt. per acre (±1.19) Superphosphate (cwt. P_2O_5)			STRAW : cwt. per acre Superphosphate (cwt. P_2O_5)		
	0.0	0.5	1.0	0.0	0.5	1.0
0.0 cwt. K_2O	21.17	20.81	20.83	22.90	20.87	20.00
0.6 cwt. K_2O	18.32	19.94	19.75	19.90	20.67	20.47
1.2 cwt. K_2O	20.06	20.56	20.92	19.60	21.37	21.83

Conclusions

There was no sign of any residual effects of the three fertilizers.

Mangolds. G. Ossenton, Esq., Mill Farm, High Halstow, Kent, 1938

3 randomized blocks of 9 plots each. Plots : 1/60 acre.

TREATMENTS : Sulphate of ammonia : None, 2 cwt., and 4 cwt. per acre, or 0, 0.4, 0.8 cwt. N per acre.

Treated town refuse* : None, 6 tons, and 12 tons per acre, or 0, 0.8, 1.6 cwt. N per acre.

Rape cake : None, 14 cwt., and 28 cwt. per acre, or 0, 0.8, 1.6 cwt. N per acre.

BASAL MANURING : 5 cwt. superphosphate and 2 cwt. sulphate of potash per acre.

SOIL : Medium loam. Variety : Orange Globe. Manures applied : April 7. Seed sown : April 15. Lifted : Nov. 11. Previous crop : Potatoes.

SPECIAL NOTE : *Town refuse screened, and fermented in silos.

STANDARD ERRORS PER PLOT : Total produce : 2.44 tons per acre or 10.0%. Plant number 1.24 thousands per acre or 5.06%.

Summary of results

	Dressings of Nitrogen None	Single	Double	*Mean*	*Increase*
	TOTAL PRODUCE : tons per acre (±1.41)				
Sulphate of ammonia	21.93[1]	22.88	29.26	*26.07*[2]	
Treated town refuse		22.71	24.06	*23.38*[2]	*−2.69*[3]
Rape cake ..		26.85	27.18	*27.02*[2]	*+0.95*[3]
Mean ..	*21.93*[1]	*24.15*[1]	*26.83*[1]	*24.30*	
Increase ..		*+2.22*[4]	*+2.68*[4]		

Standard errors : (1) ±0.813, (2) ±0.997, (3) ±1.41, (4) ±1.15.

	None	Single	Double	*Mean*	*Increase*
	PLANT NUMBER : thousands per acre (±0.716)				
Sulphate of ammonia	23.8[1]	24.4	23.5	*23.9*[2]	
Treated town refuse		24.5	24.3	*24.4*[2]	*+0.5*[3]
Rape cake ..		26.3	26.7	*26.5*[2]	*+2.6*[3]
Mean ..	*23.8*[1]	*25.1*[1]	*24.8*[1]	*24.6*	
Increase ..		*+1.3*[4]	*−0.3*[4]		

Standard errors : (1) ±0.413, (2) ±0.506, (3) ±0.716, (4) ±0.584.

Conclusions

It should be noted that sulphate of ammonia was applied at half rate per unit of N as compared with town refuse and rape cake.

The single dressing of the nitrogenous fertilizers gave an average increase of 2.2 tons roots per acre, and the double dressing a further increase of 2.7 tons per acre. There were no significant differences between the three forms of nitrogenous manure.

Rape cake produced a significant increase in plant number.

Potatoes. Land Settlement Association, Siddlesham, near Chichester, 1938

3 randomized blocks of 9 plots each. Plots : 1/60 acre.
TREATMENTS : Sulphate of ammonia: None, 2 cwt. and 4 cwt. per acre or 0, 0.4, 0.8 cwt. N per acre.
Treated town refuse*: None, 6 tons and 12 tons per acre or 0, 1.2, 2.4, cwt. N per acre.†
Rape dust: None, 14 cwt. and 28 cwt. per acre, or 0, 0.8, 1.6 cwt. N per acre.
BASAL MANURING : 5 cwt. superphosphate and 3 cwt. sulphate of potash per acre.
SOIL : Fine sandy silt, clay subsoil. Variety : Majestic. Manures applied : April 22. Potatoes planted : May 5. Lifted : Oct. 10. Previous crop : Brassicas.
SPECIAL NOTES : Potatoes passed over a 1¾ inch riddle to determine percentage ware.
* Town refuse screened, and fermented in silos.
†It was intended that the single dressing of treated town refuse should be the same as that of rape namely 0.8 cwt. N per acre. On analysis, however, the nitrogen content was found to be higher than expected so that the actual dressings were as stated above.
STANDARD ERRORS PER PLOT : Total produce : 1.44 tons per acre or 14.4%. Percentage ware : 2.44.

Summary of results

	Dressings of Nitrogen None	 Single	 Double	*Mean*	*Increase*
	TOTAL PRODUCE : tons per acre (±0.831)				
Sulphate of ammonia		10.10	11.39	*10.74*(2)	
Treated town refuse	9.21(1)	8.77	10.82	*9.80*(2)	*−0.94*(3)
Rape dust		11.19	10.23	*10.71*(2)	*−0.03*(3)
Mean	*9.21*(1)	*10.02*(1)	*10.81*(1)	*10.01*	
Increase		*+0.81*(4)	*+0.79*(4)		
Standard errors	(1) ±0.480, (2) ±0.588, (3) ±0.831, (4) ±0.679.				
	PERCENTAGE WARE (±1.41)				
Sulphate of ammonia		90.5	91.5	*91.0*(2)	
Treated town refuse	90.8(1)	90.2	91.9	*91.0*(2)	*0.0*
Rape dust		92.3	88.7	*90.5*(2)	*−0.5*(3)
Mean	*90.8*(1)	*91.0*(1)	*90.7*(1)	*90.8*	
Increase		*+0.2*(4)	*−0.3*(4)		
Standard errors	(1) ±0.813, (2) ±1.00, (3) ±1.41, (4) ±1.15.				

Conclusions

It should be noted that sulphate of ammonia was applied at half rate per unit of N as compared with town refuse and rape.

The double dressing of nitrogen gave a significantly higher mean yield than the no manure plots. There were no significant differences in yield between the three forms of nitrogenous manures. There were no significant results in the percentage ware.

Potatoes. A. W. Oldershaw Esq., Tunstall, Suffolk, 1938
East Suffolk County Council

3 randomized blocks of 9 plots each. Plots : 1/60 acre.
TREATMENTS: Sulphate of ammonia: None, 2 cwt. and 4 cwt. per acre, or 0, 0.4, 0.8 cwt. N per acre.
Treated town refuse*: None, 6.4 tons and 12.8 tons per acre, or 0, 0.8, 1.6 cwt. N per acre.
Rape dust : None, 14 cwt. and 28 cwt. per acre, or 0, 0.8, 1.6 cwt. N per acre.
BASAL MANURING : 5 cwt. superphosphate and 3 cwt. sulphate of potash per acre.
SOIL : Very poor sand. Variety : Arran Banner. Manures applied : April 21-23. Potatoes planted : April 28. Lifted : Oct. 24. Previous crop : Sugar beet.
SPECIAL NOTE : * Town refuse screened, and fermented in silos.
STANDARD ERRORS PER PLOT : Total produce : 0.651 tons per acre or 5.72%. Percentage ware : 1.40. Percentage diseased ware to total ware : 1.80.

Summary of results

	Dressing of Nitrogen			*Mean*	*Increase*
	None	Single	Double		
	TOTAL PRODUCE : tons per acre (±0.375)				
Sulphate of ammonia		11.86	12.96	*12.41*[2]	
Treated town refuse	9.78[1]	10.87	10.86	*10.86*[2]	*−1.55*[3]
Rape dust		12.44	14.22	*13.33*[2]	*+0.92*[3]
Mean	*9.78*[1]	*11.72*[1]	*12.68*[1]	*11.39*	
Increase		*+1.94*[4]	*+0.96*[4]		
Standard errors	(1) ±0.217, (2) ±0.265, (3) ±0.375, (4) ±0.306.				
	PERCENTAGE WARE (±0.808)				
Sulphate of ammonia		88.2	90.1	*89.2*[2]	
Treated town refuse	86.9[1]	87.3	88.4	*87.8*[2]	*−1.4*[3]
Rape dust		89.8	92.7	*91.2*[2]	*+2.0*[3]
Mean	*86.9*[1]	*88.4*[1]	*90.4*[1]	*88.6*	
Increase		*+1.5*[4]	*+2.0*[4]		
Standard errors	(1) ±0.467, (2) ±0.572, (3) ±0.808, (4) ±0.660.				
	PERCENTAGE DISEASED WARE (±1.04)				
Sulphate of ammonia		5.47	10.52	*8.00*[2]	
Treated town refuse	5.80[1]	6.12	8.63	*7.38*[2]	*−0.62*[3]
Rape dust		10.48	11.63	*11.06*[2]	*+3.06*[3]
Mean	*5.80*[1]	*7.36*[1]	*10.26*[1]	*7.81*	
Increase		*+1.56*[4]	*+2.90*[4]		
Standard errors	(1) ±0.600, (2) ±0.735, (3) ±1.04, (4) ±0.848.				

Conclusions

It should be noted that sulphate of ammonia was applied at half rate per unit of N as compared with town refuse and rape dust.

The increased dressings produced significantly higher yields except that the double dressing of town refuse gave the same yield as the single dressing. The percentage ware and percentage diseased ware were significantly higher with the double dressing.

Town refuse gave 1.5 tons less and rape 0.9 tons per acre more total produce than sulphate of ammonia, these differences being significant.

Similar results were obtained in percentage ware and percentage diseased ware.

Potatoes. W. E. Morton, Esq., Australia Farm, March, 1938

3 randomized blocks of 9 plots each. Certain interactions partially confounded with block differences. Plots : 1/60 acre.

TREATMENTS : 3 × 3 × 3 factorial design.
Sulphate of ammonia : None, 0.3 cwt., 0.6 cwt. N per acre.
Superphosphate : None, 0.75 cwt., 1.50 cwt. P_2O_5 per acre.
Sulphate of potash : None, 0.75 cwt., 1.50 cwt. K_2O per acre.

BASAL MANURING : Nil.

SOIL : Variable. Fine silt to heavy clay on sandy subsoil. Variety : Doon Star (once grown). Manures applied : April 20. Potatoes planted : April 22. Lifted : Nov. 3. Previous crop : Wheat.

SPECIAL NOTE : 1 cwt. of potatoes from each plot was passed over a 1¾ inch riddle to determine the percentage ware.

STANDARD ERROR PER PLOT : Total produce : 0.816 tons per acre or 9.74%. Percentage ware : 3.13.

Main effects—Interactions of sulphate of ammonia with superphosphate and sulphate of potash

Sulphate of ammonia	Superphosphate (cwt. P_2O_5) 0.00	0.75	1.50	Sulphate of potash (cwt. K_2O) 0.00	0.75	1.50	*Mean*	*Increase*
TOTAL PRODUCE : tons per acre (±0.471. *Means : ±0.272. Increases : ±0.385*)								
0.0 cwt. N	7.25	7.69	7.40	7.13	7.22	7.98	*7.45*	
0.3 cwt. N	7.62	8.20	9.46	8.12	7.87	9.29	*8.43*	*+0.98*
0.6 cwt. N	8.12	9.78	9.89	9.23	9.39	9.16	*9.26*	*+0.83*
Mean ..	*7.66*	*8.56*	*8.92*	*8.16*	*8.16*	*8.81*	*8.38*	
Increase ..		*+0.90*	*+0.36*		*0.00*	*+0.65*		
PERCENTAGE WARE : (±1.81. *Means : ±1.04. Increases : ±1.47*)								
0.0 cwt. N..	88.1	89.0	88.0	86.1	88.8	90.2	*88.4*	
0.3 cwt. N..	91.0	90.6	91.8	89.0	92.2	92.3	*91.1*	*+2.7*
0.6 cwt. N..	93.8	91.2	92.9	93.5	91.9	92.5	*92.6*	*+1.5*
Mean ..	*91.0*	*90.3*	*90.9*	*89.5*	*91.0*	*91.7*	*90.7*	
Increase ..		*−0.7*	*+0.6*		*+1.5*	*+0.7*		

Interaction of sulphate of potash with superphosphate

Sulphate of potash	TOTAL PRODUCE : tons per acre (±0.471) Superphosphate (cwt. P_2O_5) 0.00	0.75	1.50	PERCENTAGE WARE (±1.81) Superphosphate (cwt. P_2O_5) 0.00	0.75	1.50
0.00 cwt. K_2O	7.48	7.92	9.08	89.6	88.7	90.3
0.75 cwt. K_2O	7.55	8.71	8.22	93.5	91.4	88.0
1.50 cwt. K_2O	7.95	9.03	9.46	89.8	90.7	94.5

Conclusions

Sulphate of ammonia and superphosphate produced significant increases in total yield, the increases to the double dressings being 1.8 tons per acre and 1.3 tons per acre respectively. The extra increase to the second dressing of sulphate of ammonia was practically the same as the increase to the first dressing, both being significant. There was a considerable, though not significant falling off in response at the higher level of application of superphosphate. Sulphate of ammonia gave an increase of 0.9 tons per acre in the absence of superphosphate and 2.5 tons per acre with the double dressing of superphosphate, though the interaction did not reach significance. The response in total produce to the double dressing of sulphate of potash was not significant.

The double dressing of sulphate of ammonia gave a significant increase in the percentage ware of 4.2. The increase in percentage ware to sulphate of potash was not significant, while superphosphate had no apparent effect.

Sugar Beet. Tunstall, Suffolk, 1938

A. W. Oldershaw, Esq., County Organizer

4 randomized blocks of 6 plots each. Plots : 0.0130 acre.

TREATMENTS : 3 × 2 factorial design.
No manure, superphosphate and basic slag (1.0 cwt. P_2O_5 per acre).
Manures ploughed in or harrowed in.

BASAL MANURING : 3 cwt. nitrate of soda and 3 cwt. muriate of potash per acre.

SOIL : Poor sand. Variety : Kleinwanzleben E. Manures applied : May 7. Seed sown : May 7. Lifted : Nov. 23. Previous crop : Barley.

STANDARD ERRORS PER PLOT : Total sugar : 2.63 cwt. per acre or 16.2%. Tops : 0.702 tons per acre or 15.0%. Plant number : 3.28 thousands per acre or 8.14%.

Summary of results

	Ploughed	Harrowed	*Mean*	*Increase*	Ploughed	Harrowed	*Mean*	*Increase*
	TOTAL SUGAR : cwt. per acre (±1.32)				ROOTS (washed) : tons per acre			
None	16.1[1]		*16.1*[1]		5.09		*5.09*	
Super.	17.1	16.8	*17.0*[1]	*+0.9*[2]	5.39	5.27	*5.33*	*+0.24*
Slag	13.6	17.5	*15.6*[1]	*−0.5*[2]	4.53	5.62	*5.08*	*−0.01*
Mean (±0.930) . .	*15.4*	*17.2*	*16.2*		*4.96*	*5.44*	*5.16*	
Increase (±1.32)	*+1.8*				*+0.48*			
	TOPS : tons per acre (±0.351)				SUGAR PERCENTAGE			
None	4.60[3]		*4.60*[3]		15.74		*15.74*	
Super.	4.40	4.51	*4.46*[3]	*−0.14*[4]	15.75	15.90	*15.82*	*+0.08*
Slag	4.39	5.51	*4.95*[3]	*+0.35*[4]	15.00	15.45	*15.22*	*−0.52*
Mean (±*0.248*) . .	*4.40*	*5.01*	*4.67*		*15.38*	*15.68*	*15.60*	
Increase (±*0.351*)	*+0.61*				*+0.30*			

Standard Errors : (1) ±0.930, (2) ±1.32, (3) ±0.248, (4) ±0.351.

	Ploughed	Harrowed	*Mean*	*Increase*
	PLANT NUMBER : thousands per acre (±1.64)			
None	35.8[1]		*35.8*[1]	
Super.	38.3	42.3	*40.3*[1]	*+4.5*[2]
Slag	39.5	42.1	*40.8*[1]	*+5.0*[2]
Mean (±*1.16*) . .	*38.9*	*42.2*	*39.0*	
Increase (±*1.64*) . .	*+3.3*			

Standard Errors : (1) ±1.16, (2) ±1.64.

Conclusions

The yields were poor and the standard errors high. There were no significant results in sugar or tops.

Both forms of phosphate resulted in a significant increase in the plant number though there was no difference as between superphosphate and basic slag.

Harrowing the manures in increased the plant number by 3.3 thousands per acre over ploughing them in, the increase being almost significant.

Sugar Beet. Tunstall, Suffolk, 1938

A. W. Oldershaw, Esq., County Organizer

5 × 5 Latin square. Plots : 0.0129 acre.

TREATMENTS : Seventh year, no further chalk applied (see 1932 Report, p. 208, for first year's dressings).

BASAL MANURING: 3 cwt. nitrate of soda, 3 cwt. superphosphate, 3 cwt. muriate of potash per acre.

SOIL : Poor sand. Variety : Kleinwanzleben E. Seed sown : May 7. Lifted : Nov. 23. Previous crop : Clover.

STANDARD ERRORS PER PLOT : Total sugar : 4.39 cwt. per acre or 10.1%. Tops : 0.836 tons per acre or 9.09%.

Summary of results

Chalk tons per acre (1932)	TOTAL SUGAR Cwt.	*Increase*	ROOTS (washed) Tons	*Increase*	TOPS Tons	*Increase*	SUGAR PERCENTAGE	*Increase*	PLANT NUMBER Thous.	*Increase*
Mean	*43.7*		*12.50*		*9.19*		*17.48*		*39.3*	
0	*		*		*		—		*	
1	50.0		14.24		11.34		17.52		48.1	
2	55.9	*+5.9*	15.91	*+1.67*	11.43	*+0.09*	17.56	*+0.04*	51.7	*+3.6*
3	56.7	*+0.8*	16.26	*+0.35*	11.83	*+0.40*	17.42	*−0.14*	49.9	*−1.8*
4	56.0	*−0.7*	16.08	*−0.18*	11.35	*−0.48*	17.40	*−0.02*	46.6	*−3.3*
St. errors	±1.96	*±2.77*			±0.374	*±0.529*				

* The yields on the plots with no chalk were negligible.

Conclusions

The higher dressings of chalk in 1932 gave significantly higher yields of sugar than the first dressing. There was a falling off in response at the two highest dressings.

The yields of tops were practically the same at all dressings.

EXPERIMENTS CARRIED OUT BY LOCAL WORKERS

Hay. 2nd Season. Burford Grammar School, Burford, Oxfordshire, 1938

5 × 5 Latin square. Plots : 1/160 acre.

Treatments : No slag, slag at the rate of ⅓ cwt. and 1 cwt. P_2O_5 per acre. The object of this experiment is to compare annual dressings of ⅓ cwt. P_2O_5 with dressings of 1 cwt. every third year.

Basal Manuring : Nil.

Soil : Stone brash. Phosphate applied : April 29. Hay cut : June 27. (See 1937 Report p. 205).

Standard Error per Plot : 4.00 cwt. per acre or 9.70%.

Cwt. P_2O_5 1937 1938	*Mean*	0 0	⅓ ⅓	0 1	1 0
HAY : cwt. per acre	*41.3*	41.0^1	43.1^2	40.0^2	41.1^2

Standard errors : (^{1}) ±1.26, (^{2}) ±1.79.

Conclusions

No significant effects.

Hay. 8th Season. Lady Manner's School, Bakewell, 1938

3 randomized blocks of 8 plots each. Plots : 1/138 acre.

Treatments : 2^3 factorial design.

Nitrate of soda : None, 2 cwt. per acre.

Superphosphate 13.7% : None, 3 cwt. per acre.

Potash salt 30% : None, 1 cwt. per acre.

Basal Manuring : Nil.

Soil : Limestone. Manures applied : March 1-3. Hay cut : August 2. (See 1937 Report p. 206).

Standard Error per Plot : 3.63 cwt. per acre or 8.79%.

Responses to fertilizers : cwt. per acre

Mean yield : 41.2 *cwt.*

	Mean response (±*1.49*)	Differential responses (±2.11)					
		Nitrate of soda		Superphosphate		Potash salt	
		Absent	Present	Absent	Present	Absent	Present
Nitrate of soda	*+11.5*	—	—	+13.6	+9.5	+7.2	+15.8
Superphosphate	*+4.6*	+6.6	+2.6	—	—	+4.2	+5.0
Potash salt	*+4.4*	+0.1	+8.7	+4.0	+4.8	—	—

Conclusions

There was a large response to nitrate of soda of 11.5 cwt. per acre. Superphosphate and potash salt also gave significant responses of 4.6 and 4.4 cwt. per acre respectively.

Potash salt gave a significant response of 8.7 cwt. per acre in the presence of nitrate of soda, while its response in the absence of nitrate of soda was nil, the interaction being significant.

Meadow Hay. 7th Season. Lady Manner's School, Bakewell, 1938

4 randomized blocks of 9 plots each. Plots : 1/203 acre.
TREATMENTS : 3×3 factorial design.
No manure, 8 tons compost, mixed artificials applied in 1932, 1934, 1936, 1938, or in 1933, 1935, 1937.
Mixed artificials consisted of 2 cwt. nitrate of soda, 3 cwt. 13.7% superphosphate and 1 cwt. 30% potash salt per acre.
BASAL MANURING : Nil.
SOIL : Limestone. Manures applied : March 4-10. Hay cut : July 21. (See 1937 Report p. 206).
STANDARD ERROR PER PLOT : 3.34 cwt. per acre or 9.06%.

Summary of results, cwt. per acre (±1.67)

1932, 1934, 1936 and 1938 treatments	1933, 1935 and 1937 treatments Nil	NPK	Compost	*Mean* (±*0.964*)	*Increase* (±*1.36*)
Nil	24.9	27.9	33.6	*28.8*	
NPK	36.7	42.6	48.9	*42.7*	+*13.9*
Compost	36.8	37.9	42.4	*39.0*	+*10.2*
Mean (±*0.964*)	*32.8*	*36.1*	*41.6*	*36.9*	
Increase (±*1.36*) ..		+*3.3*	+*8.8*		

Conclusions

Complete artificials applied in 1938 increased the yield of hay by 13.9 cwt. per acre, while compost applied in 1938 gave an increase of 10.2 cwt. per acre, the extra increase due to artificials being significant.

Artificials and compost applied in 1937 gave significant increases in yield of 3.3 and 8.8 cwt. per acre respectively, the increase due to compost being significantly greater than that due to artificials.

Kale. Lady Manner's School, Bakewell, 1938

4 × 4 Latin square. Plots 1/102 acre.
TREATMENTS : None, 2 cwt., 4 cwt. and 6 cwt. per acre equal parts of nitrate of soda and sulphate of ammonia.
BASAL MANURING : Superphosphate 5 cwt. per acre and sulphate of potash 2 cwt. per acre.
SOIL : Limestone. Variety : Marrow Stem. Manures applied : May 12-16. Seed sown : May 13-16. Singled : 6 inches apart. Cut : Nov. 14-Dec. 14. Previous crop : Potatoes.
STANDARD ERROR PER PLOT : 2.03 tons per acre or 9.52%.

Summary of results

	Sulphate of ammonia and nitrate of soda (cwt.) 0	2	4	6	*Mean*
Tons per acre (±1.02)	17.20	20.59	22.97	24.32	*21.27*
Increase (±*1.44*) ..		+*3.39*	+*2.38*	+*1.35*	

Conclusions

There was a significant response to nitrogen, with a slight but not significant falling-off in response at the higher levels of application.

Kale. Midland Agricultural College, Loughborough, 1938

4 randomized blocks of 6 plots each in each of the two experiments. Plots : 1/50 acre.

TREATMENTS : 3×2 factorial design.
1st experiment : Nitrate of soda : None, 2 and 4 cwt. per acre as top dressing. Unthinned and thinned.
2nd experiment : Nitro-chalk : None, 2 and 4 cwt. per acre as top dressing. Unthinned and thinned.

BASAL MANURING : 25 tons farmyard manure, 6 cwt. slag, 2 cwt. 30% potash salt, 1 cwt. nitro-chalk per acre. 1 cwt. nitrate of lime given after sowing during drought period.

SOIL : Light loam. Variety : Marrowstem. Seed sown : April 21. Nitrate of soda applied : June 21. Nitro-chalk applied : June 23-25. Thinned : June 21 and 23-25. Harvested : 1st experiment, Dec. 28-Jan. 17 ; 2nd experiment, Nov. 28-Dec. 16. Previous crop : Wheat.

SPECIAL NOTE : On the thinned plots the plants were set out to 10 inches ; elsewhere no thinning of any kind was done.

STANDARD ERRORS PER PLOT : 1st experiment, 2.71 tons per acre or 8.07% ; 2nd experiment, 2.20 tons per acre or 5.95%.

EXPERIMENT I

Tons per acre (±1.36)	Nitrate of soda (cwt.) 0	2	4	*Mean* (±*0.782*)	*Increase* (±*1.11*)
Unthinned . .	34.45	32.81	34.69	*33.98*	
Thinned . .	32.89	31.80	34.61	*33.10*	*−0.88*
Mean (±*0.958*)	*33.67*	*32.30*	*34.65*	*33.54*	
Increase (±*1.35*)		*−1.37*	*+2.35*		

EXPERIMENT II

Tons per acre (±1.10)	Nitro-chalk (cwt.) 0	2	4	*Mean* (±*0.635*)	*Increase* (±*0.898*)
Unthinned . .	38.44	36.25	38.83	*37.84*	
Thinned . .	35.94	36.02	36.48	*36.15*	*—1.69*
Mean (±*0.778*)	*37.19*	*36.13*	*37.66*	*36.99*	
Increase (±*1.10*)		*—1.06*	*+1.53*		

Conclusions

Thinning gave small though not significant decreases in yield. The top dressing did not produce any significant increases, probably due to the high yields consequent on the heavy basal manuring.

Potatoes. Burford Grammar School, Burford, Oxfordshire, 1938

3 randomized blocks of 9 plots each. Plots : 1/173 acre.

TREATMENTS : The object of this experiment is to compare full dressings every third year with one-third dressings every year of artificial and equivalent organic fertilizers.
Artificials : Sulphate of ammonia, superphosphate and muriate of potash.
Organic fertilizer : Dried blood, steamed bone flour.
Full dressing contains : N 0.8 cwt. per acre.
P_2O_5 1.0 cwt. per acre.
K_2O 1.0 cwt. per acre.

BASAL MANURING : Nil.

SOIL : Stonebrash. Variety : Great Scot. Manures applied : April 29-May 2. Potatoes planted : April 19-21. Lifted : Sept. 19-21. Previous crop : Swedes and Beetroot.

STANDARD ERRORS PER PLOT : Total produce : 1.11 tons per acre or 12.4%. Percentage ware : 1.36.

1937 1938	None None	Org. None	Art. None	⅓ org. ⅓ org.	⅓ art. ⅓ art.	None Org.	None Art.	*Mean*
	TOTAL PRODUCE : tons per acre (±0.641)							
	8.39[1]	9.54	9.11	9.03	9.34	8.98	9.41	*8.95*
Increase (±0.740)		*+1.15*	*+0.72*	*+0.64*	*+0.95*	*+0.59*	*+1.02*	
	PERCENTAGE WARE : (±0.787)							
	95.6[2]	96.5	95.6	95.4	96.6	94.8	96.5	*95.8*
Increase (±0.908)		*+0.9*	*0.0*	*−0.2*	*+1.0*	*−0.8*	*+0.9*	

Standard errors : (1) ±0.370, (2) ±0.454.

Conclusions

The plots which have not yet received any fertilizer yielded less (but barely significantly so) than those receiving fertilizers, but there were no significant differences between these latter.

Sugar Beet. J. E. Barrick, Esq., Caistor, 1938
Brigg Beet Sugar Factory

6×6 Latin square. Plots : 1/93 acre.

TREATMENTS : Nitrogen at the rate of 0.0 and 0.7 cwt. N per acre, comparing sulphate of ammonia, nitrate of soda, nitro-chalk, cyanamide and nitrate of lime.

BASAL MANURING : Superphosphate and muriate of potash.

SOIL : Sand. Variety : Kleinwanzleben E. Manures applied : April 4. Seed sown : April 19. Lifted : November 4. Previous crop : Wheat.

STANDARD ERRORS PER PLOT : Total sugar : 3.70 cwt. per acre or 12.4%. Tops : 1.50 tons per acre or 14.2%. Mean dirt tare : 0.149.

Summary of results

	No nitrogen	Sulphate of ammonia	Nitrate of soda	Nitro-chalk	Cyanamide	Nitrate of lime	*Mean*
TOTAL SUGAR : cwt. per acre (±1.51)	22.0	32.0	36.8	32.1	24.7	31.9	*29.9*
Increases (±2.14)		*+10.0*	*+14.8*	*+10.1*	*+2.7*	*+9.9*	
ROOTS (washed) : tons per acre	6.33	9.20	10.82	9.37	7.18	9.36	*8.71*
Increases		*+2.87*	*+4.49*	*+3.04*	*+0.85*	*+3.03*	
TOPS : tons per acre (±0.612)	6.04	10.22	14.22	11.56	8.67	12.68	*10.56*
Increases (±0.865) ..		*+4.18*	*+8.18*	*+5.52*	*+2.63*	*+6.64*	
SUGAR PERCENTAGE ..	17.4	17.4	17.0	17.1	17.2	17.1	*17.2*
Increases		*0.0*	*−0.4*	*−0.3*	*−0.2*	*−0.3*	
PLANT NUMBER : Thous. per acre	22.7	24.5	25.3	24.4	23.1	24.5	*24.1*
Increases		*+1.8*	*+2.6*	*+1.7*	*+0.4*	*+1.8*	

Conclusions

All forms of nitrogen produced large increases in sugar per acre except cyanamide, for which the increase was small and not significant. Nitrate of soda gave a significantly higher yield of sugar than any of the other fertilizers. All forms of nitrogen gave significant increases in tops, nitrate of soda giving the greatest increase and cyanamide the smallest. The effects on plant number were also similar to those on sugar. The soil was acid, pH 5.4.

Sugar Beet, W. H. Waldock, Esq., Pode Hole, Spalding, 1938

Spalding Beet Sugar Factory

4×4 Latin square. Plots : 1/49 acre.

TREATMENTS : Nitrogen at the rate of 0.0 and 0.8 cwt. N per acre, comparing sulphate of ammonia, nitrate of soda and nitro-chalk.

BASAL MANURING : 4 cwt. of complete fertilizer providing 0.5 cwt. N, 0.5 cwt. P_2O_5, 0.6 cwt. K_2O.

SOIL : Heavy silt on clay. Variety : Johnson's Perfection. Manures applied : April 4. Seed sown : April 6, redrilled May 5. Lifted : November 9. Previous crop : Bulbs.

STANDARD ERROR PER PLOT : Total Sugar : 2.40 cwt. per acre or 11.0%. Tops : 0.759 tons per acre or 11.4%. Mean dirt tare : 0.064.

Summary of results

	No nitrogen	Sulphate of ammonia	Nitrate of soda	Nitro-chalk	*Mean*
TOTAL SUGAR : cwt. per acre (±1.20)	21.6	21.5	22.5	21.4	*21.8*
Increases (±*1.70*)		*−0.1*	*+0.9*	*−0.2*	
ROOTS (washed) : tons per acre ..	6.73	6.69	7.25	6.84	*6.88*
Increases		*−0.04*	*+0.52*	*+0.11*	
TOPS : tons per acre (±0.380) ..	6.29	6.83	7.02	6.58	*6.68*
Increases (±*0.537*)		*+0.54*	*+0.73*	*+0.29*	
SUGAR PERCENTAGE	16.0	16.0	15.5	15.6	*15.8*
Increases		*0.0*	*−0.5*	*−0.4*	
PLANT NUMBER : thous. per acre	34.6	35.0	35.0	35.0	*34.9*
Increases		*+0.4*	*+0.4*	*+0.4*	

Conclusions

In the very dry season the basal dressing of nitrogen was apparently sufficient for the needs of the crop, so that no effects of treatments were observed.

Sugar Beet. Cleyfield Estate Company, Cockley Cley, Swaffham, Norfolk, 1938

Wissington Beet Sugar Factory

5 × 5 Latin square. Plots : 1/140 acre.

TREATMENTS : None, muriate of potash, kainit (both 1.25 cwt. K_2O per acre), salt (4.75 cwt. per acre), and muriate of potash with salt.

BASAL MANURING : 4 cwt. sulphate of ammonia, 6 cwt. 16% superphosphate per acre.

SOIL : Sand. Variety : Kleinwanzleben E. Manures applied : April 8. Seed sown : April 13. Lifted : Oct. 25. Previous crop : Rye.

STANDARD ERROR PER PLOT : Total sugar : 2.65 cwt. per acre or 10.6%. Mean dirt tare : 0.075.

	TOTAL SUGAR		ROOTS (washed)		SUGAR PER-CENTAGE		PLANT NUMBER	
	Cwt.	*Increase*	Tons	*Increase*		*Increase*	Thous.	*Increase*
Mean	*25.1*		*8.36*		*14.98*		*33.7*	
Nil	19.5		6.68		14.60		32.5	
Muriate of potash ..	26.2	*+6.7*	8.58	*+1.90*	15.22	*+0.62*	36.3	*+3.8*
Salt	24.7	*+5.2*	8.37	*+1.69*	14.72	*+0.12*	33.2	*+0.7*
Muriate of pot. & salt	28.3	*+8.8*	9.33	*+2.65*	15.16	*+0.56*	33.4	*+0.9*
Kainit	26.9	*+7.4*	8.85	*+2.17*	15.18	*+0.58*	32.9	*+0.4*
St. Errors	±1.19	±*1.68*						

Conclusions

The three treatments, muriate of potash, salt and kainit, all produced significant increases in sugar but there were no significant differences between the responses. The effect of salt was greater in the absence of muriate of potash than in its presence, but not significantly so.

The increase in sugar percentage due to salt was less than the increases due to the other treatments.

Sugar Beet. Mrs. F. A. Noble, Panton, Wragby, 1938
Bardney Beet Sugar Factory

4 × 4 Latin square. Plots : 1/40 acre.

Treatments : 2 × factorial design.
Compound manure : 5 and 10 cwt. per acrs.
Salt : None and 3 cwt. per acre.
Compound manure contained 6.6% N, 4.39% Sol. P_2O_5, 0.69% Insol. P_2O_5 and 10% K_2O

Basal Manuring : 10 loads dung.

Soil : Light loam. Variety : Marsters. Manures applied : April 8. Seed sown : April 13 Lifted : November 2. Previous crop : Wheat.

Standard Errors per Plot : Total sugar : 1.33 cwt. per acre or 3.75%. Tops : 0.580 tons per acre or 9.46%. Mean dirt tare : 0.077.

Main effects and interactions of salt with compound manure

	Compound manure				Compound manure			
	5 cwt.	10 cwt.	*Mean*	*Increase*	5 cwt.	10 cwt.	*Mean*	*Increase*
	TOTAL SUGAR : cwt. per acre (±0.665. *Means* : ±*0.470. Increases* : ±*0.665*)				ROOTS (washed) : tons per acre			
None	30.3	39.4	*34.8*		7.78	10.21	*9.00*	
Salt	33.2	39.2	*36.2*	*+1.4*	8.59	10.10	*9.34*	*+0.34*
Mean	*31.8*	*39.3*	*35.5*		*8.18*	*10.16*	*9.17*	
Increase		*+7.5*				*+1.98*		
	TOPS : tons per acre (±0.290. *Means* : ±*0.205. Increases* : ±*0.290*)				SUGAR PERCENTAGE			
None	4.95	7.07	*6.01*		19.40	19.25	*19.32*	
Salt	5.52	6.98	*6.25*	*+0.24*	19.30	19.45	*19.38*	*+0.06*
Mean	*5.24*	*7.02*	*6.13*		*19.35*	*19.35*	*19.34*	
Increase		*±1.67*				*0.00*		

	Compound manure			
	5 cwt.	10 cwt.	*Mean*	*Increase*
	PLANT NUMBER : thous. per acre			
None	28.8	31.0	*29.9*	
Salt	28.9	30.8	*29.8*	*− 0.1*
Mean	*28.8*	*30.9*	*29.8*	
Increase		*+2.1*		

Conclusions

The 10 cwt. dressing of compound manure produced a significant increase in total sugar of 7.5 cwt. per acre over the 5 cwt. dressing. Salt produced a significant increase of 2.9 cwt. per acre in sugar when applied with the 5 cwt. dressing of compound manure, but with the 10 cwt. dressing salt produced no response in sugar. The larger dressing of fertilizer gave a significant increase in tops of 1.78 tons per acre, while the effect of salt was not significant.

Sugar Beet. F. Bridges, Esq., Sleaford, 1938

Newark Beet Sugar Factory

5 × 5 Latin squares. Two identical Latin squares, one of which received a dressing of dung. Plots : 1/41 acre.

Treatments : Compound manure at the rate of 0, 6, 9, 12 and 15 cwt. per acre. Compound manure contained 6.62% N, 4.39% soluble P_2O_5, 0.69% insoluble P_2O_5 and 10% K_2O.

Basal Manuring : 10 loads dung per acre to one Latin square.

Soil : Medium loam : Variety : Sharpe's Kleinwanzleben E. Seed sown : April 27. Manures applied : April 4. Lifted : Nov. 16. Previous crop : wheat.

Standard Errors per Plot : Area with dung : Total sugar : 2.96 cwt. per acre or 6.79%. Tops : 0.906 tons per acre or 8.18%. Area with no dung : Total sugar : 1.62 cwt. per acre or 5.04%. Tops : 0.511 tons per acre or 5.55%. Mean dirt tare : Area with dung : 0.086. Area with no dung : 0.106.

Summary of results

Area with dung

Compound manure cwt.	TOTAL SUGAR Cwt.	*Increase*	ROOTS (washed) Tons	*Increase*	TOPS Tons	*Increase*	SUGAR PERCENTAGE	*Increase*	PLANT NUMBER Thous.	*Increase*
Mean	*43.6*		*12.14*		*11.07*		*17.97*		*25.4*	
None	40.4		10.95		8.24		18.42		24.8	
6	44.5	*+4.1*	12.27	*+1.32*	10.57	*+2.33*	18.12	*−0.30*	26.1	*+1.3*
9	43.6	*−0.9*	12.04	*—0.23*	11.65	*+1.08*	18.12	*0.00*	25.2	*—0.9*
12	45.8	*+2.2*	12.78	*+0.74*	12.47	*+0.82*	17.88	*−0.24*	24.9	*−0.3*
15	43.9	*−1.9*	12.69	*−0.09*	12.44	*−0.03*	17.24	*−0.64*	25.3	*+0.4*
St. Errors	±1.32	*±1.87*			±0.405	*±0.573*				

Area with no dung

Compound manure cwt.	TOTAL SUGAR Cwt.	*Increase*	ROOTS (washed) Tons	*Increase*	TOPS Tons	*Increase*	SUGAR PERCENTAGE	*Increase*	PLANT NUMBER Thous.	*Increase*
Mean	*32.3*		*9.11*		*9.21*		*17.70*		*22.8*	
None	27.2		7.70		7.15		17.68		22.3	
6	32.0	*+4.8*	9.12	*+1.42*	8.66	*+1.51*	17.52	*−0.16*	23.8	*+1.5*
9	32.6	*+0.6*	9.34	*+0.22*	9.71	*+1.05*	17.48	*−0.04*	22.9	*−0.9*
12	36.2	*+3.6*	10.03	*+0.69*	10.32	*+0.61*	18.04	*+0.56*	23.6	*+0.7*
15	33.3	*−2.9*	9.36	*−0.67*	10.20	*−0.12*	17.80	*−0.24*	21.6	*−2.0*
St. Errors	±0.725	*±1.03*			±0.229	*±0.324*				

Conclusions

There was a significant response in sugar to the fertilizer, with a significant falling off in response at the higher dressings. Tops showed similar results. The response in sugar to the fertilizer was greater on the undunged plots than on the dunged plots, though this difference did not reach significance. The dunged plots were significantly more variable than the undunged plots.

Sugar Beet. A. Hodgson, Esq., Tattershall, 1938

Bardney Beet Sugar Factory

5 × 5 Latin square. Plots : 1/49 acre.

Treatments : Compound manure at the rates of 0, 6, 9, 12 and 15 cwt per acre. Compound manure contained 6.62% N, 4.39% Sol. P_2O_5, 0.69% Insol. P_2O_5 and 10% K_2O.

Basal Manuring : 12 loads farmyard manure per acre.

Soil : Sand over gravel. Variety : Strube E. Manures applied : March 24. Seed sown : April 18. Lifted : Nov. 10. Previous crop : Wheat.

Standard Errors per Plot : Total sugar : 2.36 cwt per acre or 4.96%. Tops : 1.32 tons per acre or 8.30%. Mean dirt tare : 0.057.

Summary of results

Compound manure cwt. per acre	TOTAL SUGAR		ROOTS (washed)		TOPS		SUGAR PERCENTAGE		PLANT NUMBER	
	Cwt.	*Increase*	Tons	*Increase*	Tons	*Increase*		*Increase*	Thous.	*Increase*
Mean	*47.6*		*13.97*		*15.93*		*17.02*		*23.8*	
0	44.8		13.09		13.67		17.12		23.7	
6	50.2	*+5.4*	14.44	*+1.35*	15.22	*+1.55*	17.38	*+0.26*	24.2	*+0.5*
9	48.6	*−1.6*	14.29	*−0.15*	16.19	*+0.97*	17.02	*−0.36*	23.9	*−0.3*
12	46.3	*−2.3*	13.70	*−0.59*	16.19	*0.00*	16.88	*−0.14*	23.7	*−0.2*
15	47.9	*+1.6*	14.32	*+0.62*	18.39	*+2.20*	16.72	*−0.16*	23.3	*−0.4*
St. Errors	±1.06	*±1.50*			±0.590	*±0.834*				

Conclusions

6 cwt. of compound manure gave a significant increase of 5.4 cwt. per acre in total sugar. Larger amounts of fertilizer proved less effective, the mean yield of sugar for the 9, 12 and 15 cwt. dressings being significantly below that for the 6 cwt. dressing.

There was a significant increase in the yield of tops, with no sign of a falling-of in response at the higher levels of application.

Both sugar percentage and plant number show a tendency to decrease with increasing levels of fertilizer.

Sugar Beet. E. L. Nickols, Esq., Pinchbeck, Spalding, 1938

Spalding Beet Sugar Factory

4 × 4 Latin square with split plots. Sub-plots : 1/93 acre.

TREATMENTS : Nil, 3 cwt. per acre sulphate of ammonia, 4 cwt. per acre superphosphate, 1½ cwt. per acre muriate of potash. Plots split for early and late liftings.

BASAL MANURING : 1 cwt. sulphate of ammonia, 2 cwt. superphosphate and 1 cwt. muriate of potash per acre.

SOIL : Silt. Variety : Johnsons. Manures applied : April 18. Seed sown : May 5. Lifted : Oct. 26 and Nov. 29. Previous crop : Oats.

STANDARD ERRORS PER PLOT : Total sugar : Whole plot : 2.74 cwt. per acre or 10.7%. Sub-plot : 2.47 cwt. per acre or 9.61%.

Summary of results

	No manure	Sulphate of ammonia	Super-phosphate	Muriate of potash	*Mean*	*Increase*
			TOTAL SUGAR : cwt. per acre (±1.24*)			
Lifted Oct. 25	23.2	23.2	21.2	22.2	*22.4*[1]	
Lifted Nov. 29	31.2	28.9	25.5	30.3	*29.0*[1]	*+6.6*[2]
Mean (±*1.37*)	*27.2*	*26.0*	*23.4*	*26.2*	*25.7*	
Increase (±*1.94*) . .		*−1.2*	*−3.8*	*−1.0*		
			ROOTS (washed) : tons per acre			
Lifted Oct. 25	6.85	6.88	6.08	6.54	*6.59*	
Lifted Nov. 29	9.27	8.52	7.51	9.05	*8.59*	*+2.00*
Mean	*8.06*	*7.70*	*6.80*	*7.80*	*7·59*	
Increase		*−0.36*	*−1.26*	*−0.26*		
			SUGAR PERCENTAGE			
Lifted Oct. 25	17.0	16.9	17.4	17.0	*17.1*	
Lifted Nov. 29	16.8	17.0	17.0	16.8	*16.9*	*−0.2*
Mean	*16.9*	*17.0*	*17.2*	*16.9*	*17.0*	
Increase		*+0.1*	*+0.3*	*0.0*		
			PLANT NUMBER : thousands per acre			
Lifted Oct. 25	28.7	28.6	28.2	27.7	*28.3*	
Lifted Nov. 29	26.4	26.3	25.9	25.1	*25.9*	*−2.4*
Mean	*27.6*	*27.4*	*27.0*	*26.4*	*27.1*	
Increase		*−0.2*	*−0.6*	*−1.2*		

Standard errors : (1) ±0.618, (2) ±0.874.

* For comparisons involving the difference of times of lifting.

Conclusions

The later lifting gave a significant increase in sugar of 6.6 cwt. per acre. There were no significant effects of the fertilizers. The weights of tops were recorded for two rows per half plot, but the results were too irregular to be included.

Sugar Beet. C. H. Cole, Esq., Uggeshall, Suffolk, 1938

Cantley Beet Sugar Factory

4 × 4 Latin square with split plots. Sub-plots : 1/111 acre.

TREATMENTS : Nil, 3 cwt. sulphate of ammonia, 4 cwt. superphosphate, 1½ cwt. muriate of potash. Plots split for early and late liftings.

BASAL MANURING : Humanure 4 tons per acre.

SOIL : Light loam. Variety : Kleinwanzleben E. Manures applied : May 3. Seed sown : May 5. Lifted : Nov. 1 and Dec. 16. Previous crop : Barley.

STANDARD ERRORS PER PLOT : Total sugar : whole plot : 1.80 cwt. per acre or 6.83% ; sub-plot : 2.43 cwt. per acre or 9.20%. Tops : whole plot : 0.735 tons per acre or 8.11% ; sub-plot : 0.760 tons per acre or 8.38%. Mean dirt tare : 1st lifting : 0.164, 2nd lifting : 0.132.

Summary of results

	No manure	Sulphate of ammonia	Super-phosphate	Muriate of potash	*Mean*	*Increase*
	TOTAL SUGAR : cwt. per acre (±1.22*)					
Lifted Nov. 1	25.0	22.2	22.7	23.3	*23.3*[1]	
Lifted Dec. 16	30.2	29.0	28.5	30.1	*29.4*[1]	*+6.1*[2]
Mean (±*0.900*)	*27.6*	*25.6*	*25.6*	*26.7*	*26.4*	
Increase (±*1.27*)		*−2.0*	*−2.0*	*−0.9*		
	ROOTS (washed) : tons per acre					
Lifted Nov. 1	7.80	7.02	7.48	7.29	*7.39*	
Lifted Dec. 16	9.00	8.88	8.90	9.05	*8.96*	*+1.57*
Mean	*8.40*	*7.95*	*8.19*	*8.17*	*8.18*	
Increase		*—0.45*	*—0.21*	*—0.23*		
	TOPS : tons per acre (±0.380*)					
Lifted Nov. 1	7.48	8.46	11.01	8.67	*8.90*[3]	
Lifted Dec. 16	8.13	8.61	11.47	8.75	*9.24*[3]	*+0.34*[4]
Mean (±*0.368*)	*7.80*	*8.53*	*11.24*	*8.71*	*9.07*	
Increase (±*0.520*)		*+0.73*	*+3.44*	*+0.91*		
	SUGAR PERCENTAGE					
Lifted Nov. 1	16.0	15.8	15.2	16.0	*15.8*	
Lifted Dec. 16	16.8	16.4	16.0	16.6	*16.4*	*+0.6*
Mean	*16.4*	*16.1*	*15.6*	*16.3*	*16.1*	
Increase		*−0.3*	*−0.8*	*−0.1*		
	PLANT NUMBER : thousands per acre					
Lifted Nov. 1	34.3	32.9	34.5	31.3	*33.2*	
Lifted Dec. 16	36.1	36.0	36.3	37.0	*36.4*	*+3.2*
Mean	*35.2*	*34.5*	*35.4*	*34.2*	*34.8*	
Increase		*−0.7*	*+0.2*	*−1.0*		

Standard errors : (1) ±0.608, (2) ±0.860, (3) ±0.190, (4) ±0.269.

*For comparisons involving the difference of times of lifting.

Conclusions

The later lifting gave a significant increase in sugar of 6.1 cwt. per acre, and also a small though not significant increase in tops. The only significant effect of the fertilizers was an increase of 3.4 tons per acre in tops due to superphosphate.

Sugar Beet. F. W. White, Esq., Balderton, 1938
Newark Beet Sugar Factory and Nottinghamshire Agricultural Education Committee

6 × 6 Latin square. Plots : 1/41 acre.

TREATMENTS : No manure, superphosphate and basic slag (0.72 cwt. P_2O_5), applied in January or April. As an extra treatment a higher dressing of basic slag (0.95 cwt. P_2O_5) was applied in January.

BASAL MANURING : Nil.

SOIL : Sand and gravel. Variety : Dippe. Manures applied : Jan. 6 and April 21. Seed sown : April 22. Lifted : Nov. 11-18. Previous crop : Wheat.

STANDARD ERRORS PER PLOT : Total sugar : 2.97 cwt. per acre or 7.33%. Tops : 0.716 tons per acre or 5.38%. Mean dirt tare : 0.122.

Summary of results

Cwt. P_2O_5	No manure	Superphosphate 0.72 applied		Basic slag 0.72 applied		Basic slag 0.95 applied	S.E.
		Jan.	Apr.	Jan.	Apr.	Jan.	
TOTAL SUGAR : cwt. per acre	39.4	40.9	39.1	41.8	39.6	42.7	±1.21
Increase		*+1.5*	*−0.3*	*+2.4*	*+0.2*	*+3.3*	*±1.71*
ROOTS (washed) : tons per acre	11.65	12.11	11.42	11.89	11.66	12.46	
Increase		*+0.46*	*−0.23*	*+0.24*	*+0.01*	*+0.81*	
TOPS : tons per acre . .	13.33	13.63	13.02	12.83	13.46	13.58	±0.292
Increase		*+0.30*	*−0.31*	*−0.50*	*+0.13*	*+0.25*	*±0.413*
SUGAR PERCENTAGE . .	16.85	16.85	17.13	17.60	16.98	17.12	
Increase		*0.00*	*+0.28*	*+0.75*	*+0.13*	*+0.27*	
PLANT NUMBER : thous. per acre	26.9	27.0	26.8	26.9	26.3	27.4	
Increase		*+0.1*	*−0.1*	*0.0*	*−0.6*	*+0.5*	

Conclusions

The increases in total sugar for the January applications of minerals were not significant, while there was no apparent response to the April application. There was no apparent difference between superphosphate and basic slag.

The effects of the minerals on tops were negligible.

Sugar Beet. W. Everard, Esq., Leverton, 1938
Bardney Beet Sugar Factory

6×6 Latin square. Plots : 1/80 acre.

TREATMENTS : Nil and 0.7 cwt. N per acre. Comparing sulphate of ammonia, nitrate of soda, nitro-chalk, nitrate of lime and calcium cyanamide.

BASAL MANURING : Superphosphate and muriate of potash.

SOIL : Silt. Manures applied : April 28. Variety : Johnson's. Seed sown : April 29. Lifted : November 18. Previous crop : Wheat.

STANDARD ERRORS PER PLOT : Total sugar : 2.08 cwt. per acre or 9.69%. Tops : 0.813 tons per acre or 9.99%. Mean dirt tare : 0.195.

Summary of Results

	No nitrogen	Sulphate of ammonia	Nitrate of soda	Nitro-chalk	Cyana-mide	Nitrate of lime	*Mean*
TOTAL SUGAR : cwt. per acre (±0.849)	20.2	22.2	21.9	21.1	22.2	21.5	*21.5*
Increases (±*1.20*)		*+2.0*	*+1.7*	*+0.9*	*+2.0*	*+1.3*	
ROOTS (washed): tons per acre	6.05	6.66	6.77	6.29	6.63	6.34	*6.46*
Increases		*+0.61*	*+0.72*	*+0.24*	*+0.58*	*+0.29*	
TOPS : tons per acre (±0.332)	6.47	7.54	9.15	8.46	8.84	8.34	*8.13*
Increases (±*0.469*)		*+1.07*	*+2.68*	*+1.99*	*+2.37*	*+1.87*	
SUGAR PERCENTAGE ..	16.67	16.60	16.52	16.83	16.72	16.65	*16.66*
Increases		*−0.07*	*−0.15*	*+0.16*	*+0.05*	*−0.02*	
PLANT NUMBER : thous. per acre	26.9	27.1	27.5	27.2	27.2	27.4	*27.2*
Increases		*+0.2*	*+0.6*	*+0.3*	*+0.3*	*+0.5*	

Conclusions

All forms of nitrogen produced increases in sugar per acre though none of them were significant. All forms of nitrogen gave significant increases in tops, nitrate of soda and cyanamide giving significantly higher yields than sulphate of ammonia.

ABBREVIATED LIST OF THE FIELD EXPERIMENTS

Note.—N denotes sulphate of ammonia or nitrate of soda, P denotes superphosphate, and K denotes any potash fertiliser.

ERRATA

1937 Report

p. 132. Plots 11 to 15, yields are one line too low. Sections at the bottom of the page should read : I, II, III, IV, V.

pp. 132, 133 From 1927 onwards, the dressings of sulphate of ammonia have been in units of 2 cwt. and not as reported in units of 206 lb.

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Lawes Agricultural Trust

JANUARY—DECEMBER, 1938

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