ROTHAMSTED RESEARCH

Report for 1935

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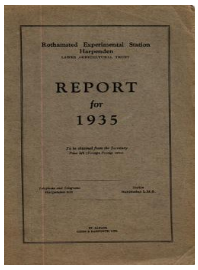

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Harpenden
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for
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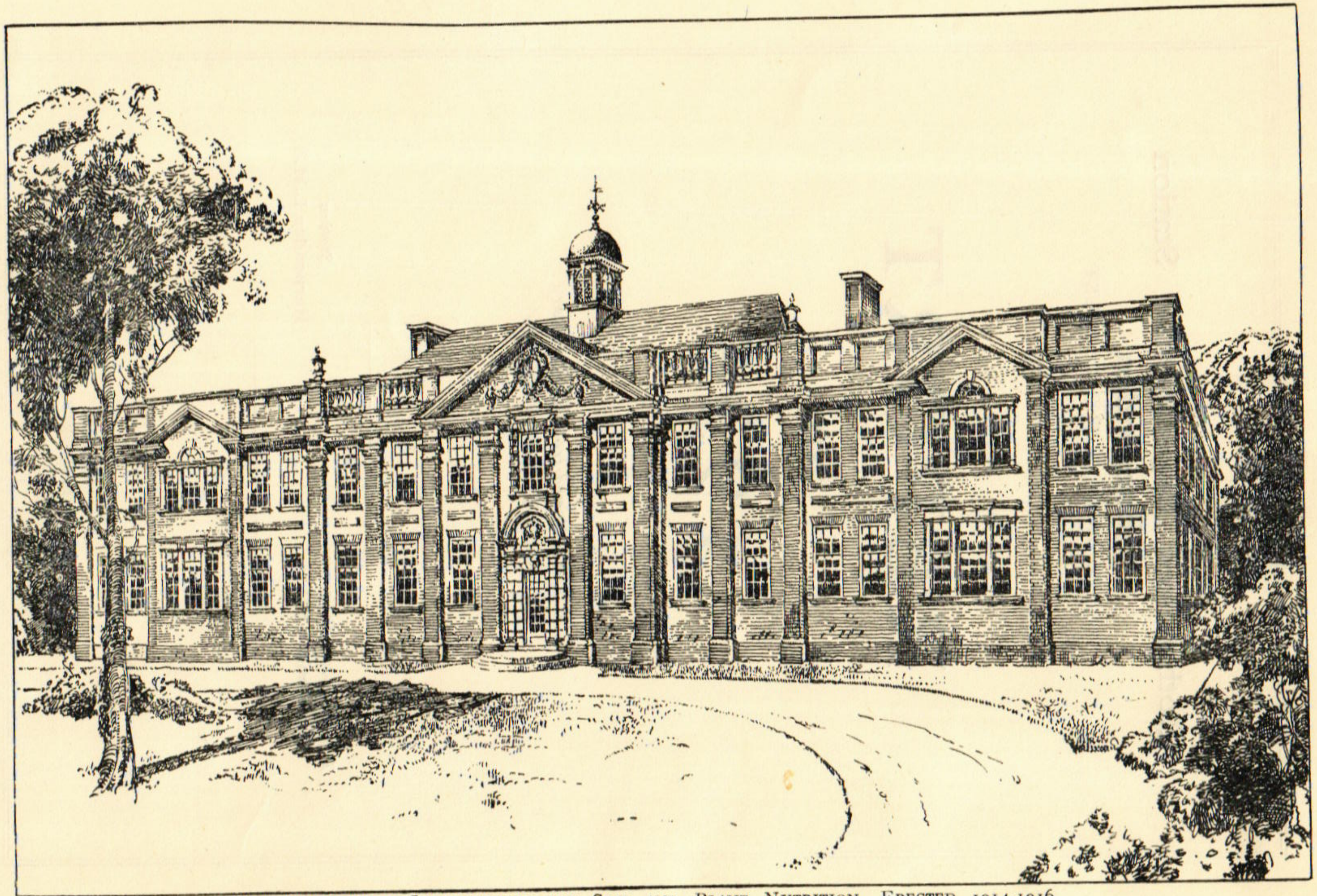

THE ROTHAMSTED LABORATORIES FOR SOIL AND PLANT NUTRITION, ERECTED 1914-1916.

REPORT
FOR
1935

CONTENTS

Experimental Station Staff

JANUARY—DECEMBER 1935.

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, M.Sc., Ph.D.,A.I.C.
Post - Graduate Research Worker	Joyce E. Rudorf
Laboratory Assistant ..	Blanche Rolt
Laboratory Attendant ..	Muriel Corke

Botanical Laboratory—

Head of Department ..	Winifred E. Brenchley, D.Sc., F.L.S.
Assistant Botanist ..	Katherine Warington, M.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. H. L. Richardson, M.Sc., Ph.D., F.I.C. Signe G. Heintze, Mag. Phil.
Post - Graduate Research Workers	G. Nagelschmidt, Dr. Phil. L. A. Dean, Ph.D. J. B. Marshall, M.Sc.
Special Assistant ..	E. Grey
Laboratory Assistants ..	A. H. Bowden F. J. Seabrook G. Lawrence H. A. Smith J. W. Dewis Alice Kingham Joan Oakley
Biochemical Section ..	A. G. Norman, D.Sc., F.I.C.
Post - Graduate Research Workers	Marian Norman, M.Sc. Anna Nowotny, Ph.D.
Laboratory Assistant ..	Joan Hellyer

Fermentation Laboratory—

Head of Department ..	E. H. Richards, B.Sc., F.I.C. (Iveagh Research Chemist)
Assistant Chemists ..	S. H. Jenkins, M.Sc., Ph.D., F.I.C.
	N. W. Barritt, M.A.
	P. W. Wigram, B.A.
Laboratory Assistant ..	Stella Ward

General Microbiology Laboratory—

Head of Department ..	D. Ward Cutler, M.A., F.Z.S.
Assistant Microbiologists	Lettice M. Crump, M.Sc., F.Z.S.
	C. B. Taylor, Ph.D.
	Annie Dixon, M.Sc., F.R.M.S.
	Jane Meiklejohn, Ph.D.
Post - Graduate Research Worker	S. R. Sengupta, M.Sc.
Laboratory Assistant ..	Mabel Dunkley
Laboratory Attendant ..	Marjorie Roberts

Insecticides and Fungicides Laboratory—

Head of Department ..	F. Tattersfield, D.Sc., F.I.C.
Assistant Chemist ..	J. T. Martin, Ph.D., A.I.C.
Laboratory Assistants ..	C. Reid
	Betty Davies
	Muriel Corke

Physical Laboratory—

Head of Department ..	B. A. Keen, D.Sc., F.R.S.
Colloid Physicist	R. K. Schofield, M.A., Ph.D. (Empire Cotton Growing Corporation Soil Physicist)
Assistant Physicists ..	G. W. Scott Blair, M.A. (Goldsmiths' Company Physicist)
	G. H. Cashen, M.Sc.
	E. W. Russell, M.A., Ph.D.
Post - Graduate Research Workers	J. V. B. da Costa, B.S.A.
	S. P. Raychaudhuri, D.Sc.
Assistant	Jessie Walker
Laboratory Assistants ..	W. C. Game
	R. F. S. Hearmon
Laboratory Attendants ..	R. Yates
	Kathleen Puddefoot

Statistical Laboratory—

Head of Department ..	F. YATES, M.A.
Assistant Statistician ..	W. G. COCHRAN, B.A.
Post - Graduate Research Workers	M. M. BARNARD, M.A., B.Sc.
	C. PELAGHIAS
Assistant Computers ..	J. M. WILSON
	FLORENCE PENNELLS
	KITTY ROLT
	PEGGY HUBBARD
	VIOLET CURGENVEN
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, B.Sc.
Soil Insects Investigations	W. R. S. LADELL, F.I.C.
Post - Graduate Research Workers	KATHERINE J. GRANT
	BETTY J. LOVIBOND, B.Sc.
	GLADYS M. WILSON, B.Sc.
	K. D. BAWEJA, M.Sc.
Laboratory Assistant ..	ELIZABETH SIBLEY
Laboratory Attendants	ANITA NEWBURY
	R. WELCH
Bee Investigations—	
Apiarist	D. M. T. MORLAND, M.A.
Bacteriologist	H. L. A. TARR, Ph.D.
Apicultural Assistant ..	A. C. ROLT

Plant Pathology Laboratory—

Head of Department ..	J. HENDERSON SMITH, M.B., CH.B. B.A.
Mycologist	G. SAMUEL, M.Sc.
Assistant Mycologist ..	MARY D. GLYNNE, M.Sc.
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	BETTY MITCHELL, B.Sc.
Glasshouse Superintendent	MARGARET M. BROWNE
Post - Graduate Research Worker ..	LINA CUNOW
Laboratory Assistant ..	ELSIE HUNT
Laboratory Attendant ..	HILDA READE
Glasshouse Attendant ..	GLADYS CURD

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
	I. W. Selman, Ph.D.
Field Superintendent ..	B. Weston
Assistants	G. F. Cole
	S. A. W. French
	R. Brett
	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	J. E. Williams
	J. E. Adams

Farm—

Manager	J. R. Moffatt, B.Sc. (Agric.), N.D.A.
Recorder	E. C. Wallis
Bailiff	H. Currant
Horsemen	F. Stokes
	C. Mepham
	W. Cain
Shepherd	G. Henderson
Stockmen	F. L. Worsfold
	A. J. Smith
Pig Experiments ..	A. Steward
Tractor Driver	J. Underhill
Labourers	W. Holland
	H. Chapman
	F. Snoxall

Library—

Librarian	Mary S. Aslin

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, 1935, and the Appointments to which they proceeded —

H. C. F. Newton, B.Sc.,
Advisory Entomologist,
West Midland Province,
Harper Adams Agricultural College
Newport, Salop.

J. Caldwell, Ph.D.,
Lecturer in Botany,
University College of the South West,
Exeter.

Temporary Workers, 1935—

In addition to those temporary workers recorded in the list of staff, the following sent officially by Governments or Universities, or coming on their own resources, have worked at the Station for various periods during the year 1935 :

(1) From the Empire :

Australia : L. W. Samuel

Canada : Dr. F. J. Greaney, Dr. W. Newton, Prof. A. Scott

Ceylon : M. Fernando

Federated Malay States : C. G. Akhurst

India : C. N. Acharya, N. P. Mehta, P. B. Richards, P. V. Sukhatme

Natal : Miss C. Osborne-Day

New Zealand : Miss Joan Anderson

Uganda : C. G. Hansford

Tanganyika : G. Robertson

(2) From Foreign Countries :

China : Miss H. Y. Liao

Denmark : J. H. Lindegaard, C. Sorensen

France : P. Potel

Holland : J. Bondewÿn

Hungary : Dr. L. Havas

Sweden : I. Granhall

(3) From British Isles :

Dr. G. W. Chapman, Miss M. N. Church, H. Edgington, G. K. McArthur, L. J. McHardy, P. S. Milne, H. W. Ogden, I. Zacopanay.

Woburn Experimental Farm

Aspley Guise, Bletchley, Beds

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Hon. Local Director ..	J. A. Voelcker, C.I.E., M.A., Ph.D.
Assistant Director ..	H. H. Mann, D.Sc., F.I.C. (Kaisar-i-Hind Gold Medal)
Chemist	T. W. Barnes, M.Sc.
Laboratory Assistant ..	R. Deacon

Farm Staff—

Assistant Manager ..	T. C. V. Bright
Horseman	G. Tyler
Stockmen	W. McCallum
	D. McCallum
	W. McCallum
Labourer	A. Sibley

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 : MONA B. STAINES

Clerks : LUCY ARNOLD, MARY ELLINGHAM

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

Publications of the Rothamsted Experimental Station

For Farmers

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

"ARTIFICIAL FERTILIZERS IN MODERN AGRICULTURE," by Sir E. J. Russell, D.Sc., F.R.S. Bulletin No. 28, Ministry of Agriculture and Fisheries, Second Edition, revised 1933. H.M. Stationery Office, or from the Secretary, Rothamsted Experimental Station, Harpenden. Cloth, 4/6 post free; or paper cover, 3/5 post free.

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

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

"THE MANURING OF POTATOES." 1/6.
(1)*"THE GROWING OF LUCERNE." 1/6.
(2) "THE CULTURE AND MANURING OF FODDER CROPS." 1/6.
(3) "GREEN MANURING: ITS POSSIBILITIES AND LIMITATIONS IN PRACTICE." 2/-.
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(6) "POWER FOR CULTIVATION AND HAULAGE ON THE FARM." 2/6.
(7) "MALTING BARLEY." 2/6.
(8) "RECENT CHANGES IN SYSTEMS OF HUSBANDRY IN ENGLAND." 2/6.
(9) "THE HERTFORDSHIRE AGRICULTURAL SITUATION: CAN IT BE IMPROVED?" 2/-.
(10) "THE GROWTH OF CHEAPER WINTER FOOD FOR LIVE STOCK." 2/6.
(11) "THE MAKING OF NEW GRASSLAND: EXPERIENCES OF PRACTICAL FARMERS." 2/6.
(12) "THE PLACE AND MANAGEMENT OF SHEEP IN MODERN FARMING." 1/6.
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(14) "MECHANISATION AND BRITISH AGRICULTURE." 2/6.
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(18)*"FOUL BROOD DISEASES OF BEES." 1/6.
(19) "THE PRODUCTION OF PIGS FOR BACON." 1/6.
(20)*"THE CAUSE AND CONTROL OF SWARMING IN BEES." 1/6.
(21) "THE USE OF ELECTRICITY IN AGRICULTURE." 2/-.

Numbers 1 to 20 inclusive are also published in book form:—
Vol. I (1-5), Vol. II (6-10), Vol. III (11-15), Vol. IV (16-20), 10/- each, postage extra.

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

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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), 36/- each. Postage extra. Obtainable from the Secretary, Rothamsted Experimental Station, Harpenden, Herts.

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

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

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

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

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

"The Physical Properties of the Soil" 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, B.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.

"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."

"GUIDE FOR VISITORS TO THE FARM AND LABORATORY, WOBURN." 1929.

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

"A DESCRIPTIVE CATALOGUE OF PRINTED BOOKS ON AGRICULTURE FROM 1471 TO 1840, CONTAINED IN THE ROTHAMSTED LIBRARY" (including Biographical notices of the authors and short descriptions of the important books). 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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1927-1928	(biennial)	2/6.	1935	(annual)	2/6.

Foreign postage extra.

"RECORDS OF THE ROTHAMSTED STAFF, HARPENDEN," containing personal notes and accounts of events at Rothamsted past and present, and of past members of the Staff. Published annually. No. 1, 1929. No. 2, 1930. No. 3, 1931. No. 4, 1933. No. 5, 1935. 2/- each. Post free. Subscription for first five issues, 7/6.

For use in Farm Institutes

"A STUDENTS 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.

Translations into other Languages during 1935

The following translations of books by members of the staff were published during the year :—

Into German : "Soil Conditions and Plant Growth" (Boden und Pflanze), 1936, by Sir E. J. Russell. D.Sc., F.R.S. Verlag von Theodor Steinkopff, Dresden and Leipzig. Trans. by Dr. K. W. Müller.

Into Russian : "The Physical Properties of the Soil," by B. A. Keen, D.Sc., F.R.S., 1935. Trans. by V. P. Jhouzé and I. U. N'elidof; edited by A. F. Joffé.

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.

Mezzotint Engravings

Mezzotint Engravings of Portraits of the Founders of the Station, Sir J. B. Lawes (H. Herkomer) and Sir J. H. Gilbert (F. O. Salisbury), by Julia Clutterbuck, A.R.E.
Signed Engravers' Proofs on India Paper, £4 4s. each.
Ordinary Lettered Proofs on hand-made paper, £2 2s. each.
To be obtained from the Secretary, Rothamsted Experimental Station, Harpenden, Herts.

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 1935-36, the Ministry of Agriculture has made a grant of £27,520 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 have provided a special assistant for the study of soil insecticides. In addition, Beet Sugar Factories Committee of Great Britain, British Basic Slag, Basic Slag and Phosphates Companies, Messrs. George Monro, the Royal Agricultural Society, Dunlop Plantations, Ltd., the Institute of Brewing and the Department of Scientific and Industrial Research and other bodies make grants for specific purposes. The result is that the Station is able to deal with problems affecting modern farming in a far more complete manner than would otherwise be possible.

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

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

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From 1926 onwards great changes took place on the farm. New and greatly improved methods of field experimentation were adopted in 1926 on all but the classical plots, which remain 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.

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. Steady development went on during 1935.

The Library is steadily growing, and now contains some 26,000 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 of great help to students of agricultural history and economics when brought together as we are doing. Gifts of books and documents to the Library will be greatly appreciated.

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

The activities of Rothamsted, however, are not confined to the British Isles, but are gradually spreading out to the Empire and other countries abroad. The International Education Board sends workers from all parts of the world to study in these laboratories. The Empire Cotton Growing Corporation has, since 1923, made a grant of £1,000 per annum for the development of investigations in Soil Physics. 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, India, 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.

In view of the great expansion of the work in recent years, it has become necessary to extend the laboratories and it is hoped to put this work in hand almost immediately. A substantial government grant has been promised subject to the condition that the Station will find a share of the cost. Subscribers and donors are asked therefore to help in the provision of these much needed extensions.

REPORT FOR 1935

The purpose of the Rothamsted investigations is to develop a science of agriculture that farmers, manufacturers, merchants, expert advisors, lecturers and others can use in their daily work. The range of the investigations includes the growth and composition of crops, the properties of soils, of fertilisers and manures, the conditions in which each can be used to the best advantage, soil management, plant diseases, insect pests, bees and other subjects. Every effort is made to ensure that the information obtained is trustworthy and to specify the conditions over which the results may be expected to hold good.

It is recognised that British agriculture is exceedingly complex, owing to the wide variations in soil and climate in these islands; and further that its economic position is liable to constant change owing to the peculiar relation in which the country stands to the towns. Only about 10 per cent. of our population is concerned in agriculture, yet this small body of people produces about 40 per cent. of the food of the entire nation, omitting such things as tea, oranges, etc., which cannot be grown here. No other body of farmers has a better record than this. Whether one judges by value of agricultural output per acre or value per man the achievement of British farmers is remarkably good.

The importance of a prosperous agriculture is widely recognised, and various devices are now adopted to ensure that the British farmer shall have a fair share of the home market. But this puts upon him the responsibility of maintaining a high standard of efficiency, and to this end it is imperative that he should have at his disposal reliable information about the materials and methods he uses, and that he should know of alternatives that he can adopt whenever he sees some reason for making a change. A method advantageous for one farmer may be quite unsuited for his neighbour, but all alike benefit from the knowledge yielded by properly conducted experiments. Our purpose is to obtain this knowledge and to put it into such form that it can be utilised by all who are interested.

This view of our function accords with the historic development of Rothamsted. Lawes himself declared, on the occasion of the opening of the Testimonial Laboratory in 1855, that "the object of these investigations is not exactly to put money into my pocket, but to give you the knowledge by which you may be able to put money into yours."

This is also the most economical procedure. Agricultural experiments are necessarily slow, each one usually taking several seasons to complete, while economic changes march quickly and *ad hoc* experiments may easily give their information too late to be of much importance. On the other hand, sound trustworthy knowledge about soils, crops, fertilisers, etc., has permanent value and can be used for the most diverse purposes. The agricultural crisis of recent years has by common consent been the worst in our history, yet farmers did not suffer as much as in some of the earlier ones. There can be little doubt that one important reason lay in the better research, educational and advisory services now available.

THE WORK OF 1935.

During the season 1935 much steady progress has been made in all departments of the Station, and some of the old work has reached a definite stage where it could be regarded as sufficiently advanced for final publication and a new direction could be given to the programme. The examination of the 50 years' experimental work at Woburn (1877-1926) has been completed, and the book is now being published by Messrs. Longmans as one of the Rothamsted Monographs on Agricultural Science. Mr. Cutler and Miss Crump have rounded off a great deal of their work, and published it also as a Rothamsted monograph, " Problems in Soil Microbiology." In both cases time and resources have been set free for new lines of investigation. Mr. Samuel has completed his survey of mycological problems and drawn up a programme, on which a start has been made.

CROP PRODUCTION

During the past few years many experiments have been made to investigate the response of the more important crops to fertilisers. The results have been disseminated among farmers, fertiliser manufacturers, agricultural experts and others interested and have influenced fertiliser recipes and practice enabling farmers to obtain better crops at little if any more cost and often at less. When one recalls the fact that some £6,000,000 was spent by farmers on fertilisers in 1934-5, according to the reports of the various fertiliser associations, it is evident that a saving of a few per cent. in the efficiency of utilisation amounts to a very respectable total.

The experiments show, however, that on our present methods the farmer recovers only a part of the fertiliser used. Of the nitrogen applied, even in the most efficient fertilisers, not more than 40 to 60 per cent. is recovered, and the lower figure is more usual than the higher. Recovery of phosphate is smaller and rarely exceeds 25 per cent. even on grassland, and after residual effects have been taken into consideration. Numerous experiments are now being made to explore the possibility of a better utilisation of the fertiliser, and in the recent experiments on sugar beet and potatoes the fertiliser tests are usually combined with cultivation tests such as time of sowing, width of spacing, method of placing manure, etc. A number of these experiments are made not only at Rothamsted and Woburn, but at outside centres also, and they are rendered the more important because so far the sugar beet crop commonly fails to respond adequately to the fertilisers used, though for what reason is not yet clear. These outside experiments are much appreciated by farmers : in the Isle of Ely, for instance, the Branch of the National Farmers' Union asked us to support their application to the County Council for a County Agricultural Organiser in order that this type of work might be developed.

GRASSLAND EXPERIMENTS

As in previous years, a number of grassland experiments have been carried out in different parts of the country to compare the values of the different types of basic slag now available or likely to become so, and also to study the effects of an even cheaper material, mineral phosphate. These experiments are carried out under the ægis of the Ministry of Agriculture Basic Slag Committee, and at the request of the slag makers and largely at their expense; they are being continued and extended to include certain new types of slag resulting from changes in the method of steel making. The result has been to prove the general superiority of high soluble basic slag over other forms, although the low soluble slag and the mineral phosphate both have value in certain conditions which are gradually being discovered. Already these investigations have had the very useful result of increasing the proportion of the agriculturally effective slags as against those of less agricultural value: this is shown by the following figures of deliveries of ground basic slag in Great Britain :—

	Deliveries, Tons			Percentage of Total Deliveries	
	High Soluble (80% or more)	Low Soluble	Total	High Soluble (80% or more)	Low Soluble
1924-1925 ..	126,025	117,514	243,539	51.8	48.2
1929-1930 ..	222,342	83,407	305,749	72.7	27.3
1934-1935 ..	203,070	77,353	280,423	72.4	27.6

The new medium soluble slags, however, present special difficulties in that they show greater differences in effect than can be accounted for by their solubility in citric acid. With the taking over of a considerable area of additional grassland in 1934, it has become possible to arrange for grassland experiments to be made at Rothamsted also, and plans for these are being worked out. An investigation is being undertaken at the request of the Royal Agricultural Society to ascertain the effect on grassland of feeding cake to the animals grazing there: in particular to discover how far any improvement effected can be related to the composition of the cake and how long such improvement lasts. Unfortunately it has not yet been found possible to design a completely satisfactory grazing experiment: the older types of experiment do not satisfy modern statistical tests. An attempt is being made this year to overcome the difficulty by fencing off small areas within the grazed plots for short periods and weighing and analysing the herbage produced.

ARABLE CROPS.

Sugar Beet. These experiments are carried out under the ægis of the Sugar Beet Research and Education Committee of the Sugar Beet factories and the Ministry of Agriculture.

Spacing Distance. During the past three years the effects of 10-, 15- and 20-inch spacings have been tested. The results have varied with the season, but on the average of the three years no marked effects have been produced by differences in spacing.

Effect of Spacing: yields of washed roots; tons per acre.

	Rothamsted				Woburn			
	1933	1934	1935	Mean	1933	1934	1935	Mean
20-in. rows ..	5.5	14.5	11.4	10.5	8.5	18.3	11.9	12.9
15-in. rows ..	6.5	13.7	10.7	10.3	9.0	19.2	12.9	13.7
10-in. rows ..	7.6	13.9	11.1	10.9	10.2	17.9	13.0	13.7

In 1933 the yields at both centres increased steadily as the spacing narrowed ; but not in the later years. The yields in 1933 were poor, and the beet remained small however wide the spacing, so that a higher plant number meant a higher yield. In 1933, narrower spacing increased the sugar percentage, but it was without effect in 1934 and 1935 and on the average it was not worth the additional hand labour required. The spacings in the factory series of sugar beet experiments vary from 18 to 22 inches.

Effect of sulphate of ammonia at different spacings. Sulphate of ammonia had no effect on yield at Rothamsted in 1933, but in both later years its effects were greatest at the narrowest spacing. At Woburn there were significant responses to sulphate of ammonia in 1933 and 1935 ; in 1933 the response increased as the spacing narrowed, but not in 1935, and on the average there was little difference between the three spacings, the 15-inch spacing giving the highest mean response.

Responses to sulphate of ammonia (3 cwt. per acre) at different spacings.
Washed roots (tons per acre)

	Rothamsted				Woburn			
Spacing	1933	1934	1935	Mean	1933	1934	1935	Mean
20-in.	−0.15	1.72	1.25	0.94	0.83	0.06	1.15	0.68
15-in.	0.36	0.78	2.22	1.12	2.91	−0.72	1.83	1.34
10-in.	0.09	2.32	2.83	1.75	2.94	−0.48	0.31	0.92
Mean	0.10	1.61	2.10	1.27	2.23	−0.38	1.10	0.98

There are indications that sulphate of ammonia had less harmful effect on sugar percentage at the narrower spacings, but the effect was small and not significant. The mean yields of total sugar, in cwt. per acre for the three years 1933, 1934 and 1935, were :

	Sulphate of ammonia per acre	20-in.	15-in.	10-in.
Rothamsted ..	None	33.4	32.6	33.8
	3 cwt.	35.8	35.8	39.0
Woburn	None	42.6	44.1	44.7
	3 cwt.	43.1	47.6	47.3

At Rothamsted there is little difference between the mean yields with the 20- and 15-inch spacings, whether nitrogen was applied or not ; with the 10-inch spacing, however, the application of nitrogen gave an increased response of about 3 cwt. of sugar. At Woburn the results for the 15- and 10-inch spacings are similar and show an increased yield over the wide spacing of 2 cwt. in the absence of nitrogen and 4½ cwt. in the presence of nitrogen. The indications at both centres are, as might be expected, that nitrogen produces a greater effect at narrower spacings.

Bolters. In the Rothamsted experiment of 1935 about 18 per cent. of the plants sown at the earliest date (March 15) bolted. In three of the experiments at Bardney and Brigg the proportion was about 5 per cent. and in one it was less than 1 per cent. At one centre about 25 per cent. bolted and an experiment was made involving four treatments : (1) untreated, (2) woody bolters pulled, (3) woody bolters pulled, other bolters cut in July, (4) all bolters cut in July. Some of the plants cut in July did not again bolt. The average weights per root were :

	Good beet	Woody bolters	Non-woody bolters	Cut and not bolted
Average weight per root (lb.) ..	1.28	0.79	1.30	1.18
Sugar, per cent. ..	17.71	17.02	17.11	17.23

The chief loss from bolters is that the woody ones weigh about 40 per cent. less per root than the others, although in all bolters the sugar percentage is slightly reduced. Since about 60 per cent. of the bolters were woody the loss of sugar on all bolters averaged about 25 per cent. and on the whole crop was about 6 per cent. This was much smaller than the rather alarming appearance of the bolters on the field had suggested. This estimate takes no account of the effect which the bolters might have on the growth of neighbouring plants which did not bolt.

At Rothamsted, where most of the bolters were woody, the results were :

	Good beet	Bolters
Average weight per root (lb.)	0.61	0.48
Sugar, per cent.	16.49	16.15

As before the average loss in sugar per bolter is about one quarter.

The cutting of the bolters in July proved very successful, giving an increase of 3 cwt. per acre in total sugar.

The standard fertilisers affected the percentage of bolters as follows :

Percentage of bolters

	Sulphate of ammonia			Superphosphate			Sulphate of potash		
	None	One dose	Two doses	None	One dose	Two doses	None	One dose	Two doses
Caistor ..	2.9	4.7	6.1	4.2	4.8	4.9	4.2	4.9	4.9
Scotton	1.4	2.8	3.4	2.2	2.8	2.8	2.4	2.7	2.6
Methering-ingham	4.7	5.7	7.3	4.8	6.4	6.5	5.0	6.4	6.3
Rothamsted	13.0	20.0	22.3						

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All three fertilisers increased the percentage of bolters, the increase being greatest for sulphate of ammonia, which had also the greatest effect on yield. For potash and phosphate the single and double dressings behaved alike, whereas sulphate of ammonia gave a more uniform increase. However, the effect is unimportant and is well covered by the increases in yield given by the sulphate of ammonia at all four centres.

The amount of bolting at Rothamsted was also affected by the width between the rows, decreasing as the spacing narrowed.

	Spacing.		
	20 in.	15 in.	10 in.
Percentage of bolters	22.3	18.1	14.9

Effect of Fertilisers on Yield.

The Staffs of the Sugar Beet factories generously co-operated in an extensive series of manurial experiments and we wish to record our deep indebtedness to them for their help. An elaborate series of chemical examinations of the various soils is being carried out and is already yielding most valuable information about the relations between soil properties and fertiliser responses. The average yields for all the factory experiments of **1935** were :

	Sulphate of Ammonia.			Super-phosphate.			Muriate of Potash.		
Cwt. per acre ..	0	2	4	0	3	6	0	1¼	2½
Roots, tons per acre	8.94	9.58	10.07	9.46	9.55	9.58	9.43	9.59	9.58
Tops, tons per acre	6.86	8.12	9.42	8.03	8.17	8.20	8.12	8.18	8.10
Sugar, per cent ..	17.22	16.99	16.59	16.95	16.91	16.95	16.80	16.96	17.04
Sugar, cwt. per acre	30.8	32.7	33.5	32.2	32.3	32.6	31.8	32.6	32.7
Purity, per cent. ..	88.2	88.1	87.5	87.9	87.9	88.0	87.8	87.8	88.0

Mean Yield per acre.		Increase in sugar in cwt. per acre for		
Washed Roots. tons.	Sugar. cwt.	4 cwt. sulphate of ammonia.	6 cwt. super-phosphate.	2½ cwt. Muriate of potash.
9.53	32.4	+2.7	+0.4	+0.9

Heart-rot in Sugar Beet.

For the first time at Rothamsted a severe attack of "heart-rot" in sugar beet was found on the plots of the spacing, sowing-date, nitrogen experiment (*see* p. 23). The disease was rather localised in its occurrence. One block of the experiment was much more seriously affected than the rest, and beet in other parts of the same field were practically free from the disease. The percentage of plants showing symptoms decreased with later sowing. The disease is attributed to boron deficiency and is being further studied.

POTATOES. At Rothamsted the effect of time of application of the fertilisers was studied, the dung being either ploughed in during November or applied in the bouts in spring, and the artificials either broadcast before ridging up or applied in the ridges. In each case application in the bouts proved the better. The mean yields were, in tons per acre :

	Fertiliser Applied. Before bouting.	In the bouts.
Dung	7.15	8.06
Complete artificials	7.58	9.70

The increases due to dung were 3.4 tons per acre where no superphosphate or muriate of potash were given and 1.3 tons per acre where they were present. Sulphate of ammonia applied alone had no effect, but with minerals or dung it gave an increase of 2.1 tons per acre.

The effects of treatments on the percentage of ware were similar to those on yield.

The potatoes were lifted in October, and the produce stored in a clamp in the usual way until February, the produce of the different plots being kept distinct. The loss in weight averaged 4.5 per cent. It was less for dung in the bouts (4 per cent.) than for dung ploughed in (6 per cent.).

About 7 per cent. of the potatoes went bad on storing. Dung and minerals both increased the proportion of bad potatoes by 2 per cent.; sulphate of ammonia had little effect. Further, the potatoes did not keep so well when dung was applied in the bouts as when it was ploughed in, the loss being 8.7 per cent. against 6.3 per cent. On the other hand, artificials applied in the bouts gave in this experiment better keeping potatoes than artificials broadcast before bouting.

Percentage ware. In view of the regulations of the Potato Marketing Board it is now important to study the effects of fertilisers on the proportion of ware as well as on total yields. The numbers of experiments used in the following summary are 3 in 1932, 6 in 1933, 13 in 1934 and 8 in 1935. The amounts of manures were fairly uniform and the results have been reduced to fixed amounts of fertiliser. The size of riddle was generally $1\frac{1}{2}$ to $1\frac{3}{4}$ inches. The average percentage of ware varied, with one exception, from 60 per cent. to nearly 100 per cent.

The mean increases in percentage ware given by sulphate of ammonia (3 cwt. per acre), superphosphate ($3\frac{1}{2}$ cwt. per acre), sulphate or muriate of potash (2 cwt. per acre) and poultry manure (about 1 ton per acre) were :—

	Centres with significant yield response	Other centres.
Sulphate of ammonia	1.65 (20)	−0.36 (10)
Poultry Manure	1.43 (9)	−1.82 (4)
Superphosphate	0.81 (7)	−1.16 (12)
Sulphate or muriate of potash	10.46 (7)	0.82 (8)

The figures in brackets show the numbers of experiments over which the means are taken.

The fertilisers increased the percentage ware only where they also increased yield. Where there was an increase in yield, potash consistently increased the percentage ware, giving a striking average increase of 10 per cent. The other three fertilisers had smaller and less consistent effects. There was a large proportion of very small responses for all fertilisers, but these mostly occurred at centres where the mean percentage ware was over 90 per cent. and little further increase was possible.

Four experiments included farmyard manure ; all gave a clear response in yield and two gave a large increase in percentage of ware :—

	Mean per cent. ware	Increase in per cent. ware with farmyard manure
Rothamsted 1932 (15 tons)	93.5	0.5
,, 1934 (20 tons)	87.2	1.2
,, 1935 (15 tons)	70.8	17.7
Wimblington 1935 (8½ tons)	73.3	16.6

Outside Centres. The manurial experiments on potatoes were made as usual at a number of centres, which may be conveniently grouped as fenland and as mineral soils.

Fenland Soils.

Yield, Tons per acre, Total Crop, 1935.

Centre.	Standard Error.	Sulphate of Ammonia.			Super-phosphate.			Sulphate of Potash.		
		0	cwt. 1½	cwt. 3	0	cwt. 4½	cwt. 9	0	cwt. 1½	cwt. 3
Light peaty soils										
Thorney . .	±0.466	7.98	9.00	8.23	8.05	8.16	9.00	7.86	8.50	8.85
Mepal . .	±0.414	8.81	9.54	10.12	8.91	9.57	9.99	7.16	9.84	11.47
Wimblington	±0.143	6.66	—	7.61[1]	6.90	7.38[1]	—	6.54	—	7.74[1]
Heavy Fen soils										
March . .	±0.314	5.23	7.04	8.13	6.15	6.93	7.32	6.71	7.18	6.51
Little Downham	±0.194	3.50	5.03[2]	6.53[2]	3.91	5.34	5.81	4.73	5.29[3]	5.03[3]

(1) Sulphate of ammonia 2½ cwt. ; Superphosphate 6 cwt. ; Sulphate of potash 2½ cwt.
(2) Sulphate of ammonia 2½ and 5 cwt.
(3) Sulphate of potash 1 and 2 cwt.

At Thorney responses were not very marked, but at Mepal nitrogen and especially potash acted well, the increase for the 3 cwt. of sulphate of potash being 4.3 tons per acre. At Wimblington all three fertilisers gave a significant increase. Dung proved very effective ; 8½ tons of dung gave an increase of 3.70 tons in absence of potash and 1.24 tons when potash was present, this interaction being significant.

On the heavy soils nitrogen and phosphate did well, but there was no response to potash. The experiment at Little Downham was planted with early potatoes, but they were cut down by the great frost of 17th May and allowed to stand later than usual. They yielded well and responded markedly to fertilisers.

Mineral Soils

The experiments on mineral soils fall into two groups, one testing the effects of the separate fertilisers, as above, the other showing the action of increasing levels of a mixed fertiliser.

Yield, tons per acre, total crop, 1935

Centre.	Standard Error. tons.	Sulphate of Ammonia. None	S'gle	D'ble	Super-phosphate. None	S'gle	D'ble	Sulphate of Potash. None	S'gle	D'ble
Deep silt.										
Wisbech ..	±0.346	10.38	10.67[1]	10.76	10.22	11.02[1]	10.56	10.42	11.12[1]	10.28
Light loam.										
Midland College	±0.279	8.64	8.37[2]	8.61	—	—	—	8.60	8.24[2]	8.79
Warp.										
Owston Ferry Lincs.	±0.396	—	—	—	—	—	—	9.14	10.54[3]	10.97
Heavy.										
Cadishead, Lancs. ..	±0.403	—	—	—	3.63	4.88[4]	—	—	—	—

(1) Single sulphate of ammonia 2 cwt.; single superphosphate 4 cwt.; single sulphate of potash 2 cwt.
(2) Single sulphate of ammonia 1½ cwt.; single sulphate of potash 1½ cwt.
(3) Single sulphate of potash 1 cwt.
(4) Single superphosphate 5 cwt.

There was a response to potash at the warp land centre at Owston Ferry even in presence of dung, and to phosphate on the heavy soil at Cadishead. At the other two centres the usual dressing of dung produced maximum yields.

Yield, tons per acre, total crop, 1935
Increasing levels of complete Fertiliser.

	Fertiliser cwt. per acre. 0	4	8	12	16	Standard Error.
Light loam.						
Midland College, Notts.	7.83	8.02	7.79	7.94	—	±0.355
Sandy.						
Messingham, Lincs. ..	5.26	6.88	8.70	9.74	9.81	±0.379
Limestone						
Grayingham, Lincs. ..	8.47	9.03	9.33	9.31	9.64	±0.396

Dung was given at all centres. At Messingham there was a good response, but a significant falling off in effectiveness at the higher levels of manuring. At Grayingham the response though small was significant and proportional to the dressing applied.

BEANS. In 1934, the effects of dung, nitrochalk and muriate of potash on the yield of beans were studied, and in 1935, superphosphate was included and two spacings of the rows were tried. The mean yields were :—

	Mean Yield cwt. per acre.	Increase due to Dung. 10 tons per acre.	Nitro-chalk 0.4 cwt. Nitrogen per acre.	Super-phosphate 0.6 cwt. P_2O_5 per acre.	Muriate of Potash 1.0 cwt. K_2O per acre.
1934 Grain	18.7	*2.3*	0.6	—	1.6
Straw	15.0	*2.1*	0.6	—	1.0
1935 Grain	21.0	*5.6*	1.2	−2.0	*2.7*
Straw	26.3	*9.8*	2.4	−1.7	2.8

Significant increases are printed in italics

The mean yields and the effects of fertilisers were greater in 1935 than in 1934. Dung gave large increases in both years but especially in 1935. Nitrochalk gave slight but not significant increases: superphosphate had no effect, the apparent depression in 1935 not being significant. Muriate of potash apparently increased

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the yield in both years ; the effect for grain in 1935 was significant, and that for straw almost so. The result is interesting for, apart from potatoes, most crops on the heavy Rothamsted soil are not very responsive to potash.

The 18 inch spacing of the rows gave an increased yield over the 24 inch spacing of 2.8 cwt. per acre in grain and 4.6 cwt. per acre in straw. The response to muriate of potash was significantly greater for the wide than for the narrow spacing and there was an indication of a similar effect for dung. This result was unexpected, for with narrow spacing individual plants have a more restricted nutrient supply than with wide spacing, and might be expected, therefore, to show greater responses to added fertilisers as indeed the sugar beet did. (p. 23.)

WHEAT. The question when best to apply nitrogenous fertiliser to wheat has been much studied. Very variable results have been obtained, the effect of the nitrogen depending largely on the weather. Excessive rainfall may wash the nitrogen beyond the range of the plant roots, while lack of rain may so limit growth that additional nitrogen, even if taken up by the plant, could not be utilised.

The influence of variable water-supply can be eliminated in pot-culture, and in these conditions Dr. Watson found that nitrate of soda gave the same increase of grain yield at whatever time it was applied from sowing time to the end of May. A still later application, after ear emergence in June, had no effect on yield, although the nitrogen was as fully taken up as before. The yield of straw, however, fell off steadily with later application, but the grain was larger and of higher nitrogen content than for early application. This suggests that application towards the end of May is likely to be most efficient, since the yield of grain is the same as for early application, while the quality is better and the increase of the straw, and consequently the potentiality for lodging, is less.

The results of field experiments at Rothamsted and Woburn are consistent with this view. From 1926 to 1931 seven complex experiments were carried out at Rothamsted, in which early and late dressings of sulphate and muriate of ammonia were applied. The average responses were :—

Increase produced by 0.2 *cwt. N. per acre. Mean of sulphate and muriate of ammonia, Rothamsted.*

	Applied early (March)*	Applied late (May)*	S.E.
Grain } cwt. per acre	1.12	0.81	±0.23
Straw } cwt. per acre	3.63	2.76	±0.27

* Except for one " early " application on April 11th, and one " late " application on June 5th.

The difference was not significant for grain, but it was for straw, late application giving significantly less increase than early application.

A second series of experiments was begun in 1934, at Rothamsted and Woburn, in which a wider range of times of application was tested. In 1934 no significant increases were obtained: at Rothamsted,

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the yield without nitrogen was already very high (35 cwt. grain per acre); and at Woburn the standard error was abnormally large, though a fall in straw yield with later application was suggested. In 1935, January application gave the greatest straw yield at Rothamsted and Woburn. For later applications the increase in straw yield fell steadily, as in the other experiments. The inferiority of seed-bed application compared with the spring dressings is in agreement with the Broadbalk results.

In 1935 nitrogenous fertilisers again gave no significant increase in grain yield at Rothamsted. On the other hand, at Woburn, there was a significant response, though as in the pot experiment, the time of application caused no difference in the result.

Wheat is commonly grown at that stage in a rotation when the fertility of the soil is at its highest. The comparatively small increase of grain yield in the 1926-1931 series of experiments at Rothamsted, and the absence of any response in 1934 and 1935, raises the question whether nitrogenous fertiliser is necessary for wheat on land in good heart.

Early spring applications of nitrogen frequently produce spectacular increases in the thickness, height and colour of the wheat in May, when tillering is at its maximum and elongation of the shoots is beginning, while the effect of later dressings is much less obvious. This was shown by counts of shoots and measurements of height at Woburn in 1934 and 1935. But these marked differences were not accompanied by corresponding increases in grain yield. The popularity of early dressings may be partly due to this obvious effect on spring growth. A lush early growth, however, may mean only a heavier straw crop and difficulties at harvest due to lodging, with no advantage in extra grain yield.

This does not apply, however, to systems of farming involving frequent corn crops, with little dung and where wheat does not follow a ley, a leguminous crop or a fallow.

Malting Barley

In the autumn of 1934 and again in 1935 conferences were held at Rothamsted on the growing of malting barley. They took the form of an exhibition of barley samples sent in by farmers from all parts of the country, and valued by the Barley Valuation Committee of the Institute of Brewing.

In both seasons the summers were dry and the harvesting conditions very good. In 1935, however, the spring was much colder and wetter than in 1934, and growth started in a moister soil. The rainfall at Rothamsted was :—

	1933-34	1934-35
October to May inclusive, inches	11.64	19.94

On May 17th, 1935, a severe late frost caught some of the autumn sown barleys in the early stages of ear formation. After a wet and cheerless early June the weather turned drier than in 1934 and most of the growers had practically no rain from mid-June till after harvest, though some had showers in mid-August.

The grading of the samples was as follows :—

	1934 No.	1934 per cent.	1935 No.	1935 per cent.
Grade I	6	3.2	2	0.7
Grade II	4	2.1	12	4.4
Grade III	13	6.9	37	13.7
Grade IV	22	11.6	58	21.5
Grade V	52	27.5	83	30.8
Grade VI	65	34.4	60	22.2
Grade VII (grinding)	27	14.3	18	6.7
Total	189	100.0	270	100.0

Each stage in grading represents about 5/- per quarter in value. Most of the samples fall into Grades V and VI, and very few reached the top grades of high quality. As observed before, the nitrogen content of the grain was related to the grading for a particular variety : for the Norfolk Spratt Archer of 1935 the values were :

Grades	I	II	III	IV	V	VI	VII
Per cent. Nitrogen in dry grain	1.28	1.33	1.41	1.42	1.45	1.53	1.53

An examination of the varieties sown gave the following results:

Number of samples of Barley 1934 *and* 1935.

	Plumage-Archer.	Spratt-Archer.	New Cross.	Plumage.	Other varieties.
Kent	17	—	—	—	—
Essex	20	10	—	—	5
Norfolk	11	85	11	1	7
Suffolk	7	16	3	—	4
Lincolnshire	6	18	14	2	3
Yorkshire	6	2	—	15	3
Somerset	12	11	7	1	1
All Counties	133	199	44	27	52

Kent and Essex sent mostly Plumage-Archer : Norfolk sent Spratt-Archer : Plumage was received in any quantity only from Yorkshire. Spratt-Archer and Plumage-Archer together accounted for almost three quarters of the samples.

Most of the samples came from medium and light soils : few from heavy soils : one third were from soils on or close to chalk, limestone, oolite, or stone brash.

	Number of soils, both years. Heavy.	Medium.	Light.	Total.
Calcareous	9	85	52	146
Not calcareous	90	81	115	286
Total	99	166	167	432
Per cent. of Total.				
Calcareous	2	20	12	34
Not calcareous	21	18	27	66
	23	38	39	100

About 14 per cent. of the samples in each season were autumn sown, and these usually graded better than the spring sown barleys. Thus for the two years :

In grades I, II, and III.	35 per cent. were autumn sown.
In grades IV, V.	12 per cent. ,, ,, ,,
In grades VI, VII.	8 per cent. ,, ,, ,,

Certain districts favoured autumn sowing much more than others, for example, in 1934, nearly half the barleys from Essex had been autumn sown and in 1935 nearly three-quarters.

In Norfolk barley now commonly follows sugar beet instead of swedes and turnips. Elsewhere, however, it still often follows turnips. Apparently it rarely follows potatoes.

Preceding Crops.

Barley after	1934 All counties.	1935 Norfolk.	1935 Others.	1935 All counties.	Both years total.
Cereals ..	90	22	69	91	181
Beet and Mangolds ..	38	58	39	97	135
Swedes, turnips, kale ..	19	10	30	40	59
Clover, peas, etc.	15	5	10	15	30
Potatoes ..	2	—	3	3	5
Bare and half fallow ..	3	—	1	1	4
Other crops ..	1	2	6	8	9

Much information was obtained in regard to the manuring of the barley. It is no longer a starvation crop. The experiments made by Rothamsted under the Institute of Brewing Research scheme during the last ten years showed clearly the advantage of suitable manuring when care was taken not to lodge the crop. This result has clearly passed into practice. Of the 270 samples sent in in 1935, 159 had received manure, 124 had received nitrogenous fertiliser, and no less than 61 of these had followed beet, turnips, or some other crop receiving dung, showing that the growers were prepared to give nitrogen even on land already in good condition. Some 51 crops had received compound fertilisers, which in 21 cases were the new high grade materials containing ammonium phosphate ; but many growers preferred to make their own mixtures.

EXPERIMENTS ON VEGETABLE CROPS

The importance of vegetable crops has considerably increased during recent years. Thus, for certain of the more important crops, the acreage returns for 1922 and 1934 are as follows :

Crop.	Acreage. 1922	1934	Increase per cent.
Carrots	14084	16432	+16
Onions	3557	2099	−59
Cabbage	27954	36981	+32
Brussels Sprouts	14951	34048	+128
Cauliflowers and Broccoli ..	10475	20107	+92
Celery	5282	7510	+42
Rhubarb	5718	8233	+44
Green beans	12907	16833	+30
Green peas	50894	74363	+45

Thus, with the exception of onions, there has been a substantial increase in the acreage planted with vegetables in recent years. The value per acre of the vegetable crops is also high; the actual prices realised depend greatly on quality, supplies, and the effect of weather on demand.

An estimate of the annual supplies and values of vegetables for human consumption has recently been made* from which may be derived the following data relating to the years 1930-32:

Crop.	Av. Yield per acre, tons.	Gross Value† per acre, £
Outdoor Cabbage lettuce	8	75
Celery	10	60
Broccoli and Cauliflower ..	8	71
Spring Cabbage and Cabbage Greens	7	51
Autumn Cabbage	9	40
Sprouts	3.7	53
Green Peas	2.2	30
Ripe Onions	7	39
Topped Carrots	11.7	50
Red Beet	12	48

† Freight and market charges to be deducted.

Prices also have been well maintained as compared with general farm produce, thus the agricultural index of all vegetables in 1934 was 143 (1911-13=100) whereas the general index of agricultural produce for the same year was 114.

The first experiments on vegetable crops conducted from Rothamsted, using the new technique, began in 1931, on winter cabbages, Brussels sprouts, and first early potatoes. There have now been put on record in the Station Reports some fifty experiments on vegetable crops carried out at Rothamsted, Woburn, outside centres, and by local workers operating general schemes of investigation administered from Rothamsted. The rapid expansion of this work was rendered possible by the investigation on the value of dried poultry manure put in hand by the Ministry of Agriculture and controlled from this station. It was decided to test this manure as

* "Min. Agric. Economic Series." No. 25, 1935. P. 172.

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far as possible on market garden crops since its most promising outlet would probably be for small scale intensive cultivation.

Experience has shown that experiments with vegetable crops, although in most cases rather more exacting than with farm crops, offer no insuperable difficulties. As will be seen later, standard errors tend to be a little higher than the average of large scale root crops, but none the less a considerable number of statistically significant fertiliser effects will be found in the tables that follow. On the other hand certain crops have shown very small or even negative effects. Early potatoes, carrots, onions, strawberries have all been disappointing in this respect. The experiments are, however, only a first approach to a wide subject and many more will be required to obtain an adequate view of the fertiliser responses of vegetable crops.

More has been done with Brussels sprouts than with any other crop, so that the results of the experiments on the growth of this plant will be set out first. There are thirteen experiments with sprouts on record, but one at Rothamsted was practically a failure owing to damage by wood pigeons. Of the twelve good experiments, all show the effect of nitrogen as sulphate of ammonia usually at several rates of dressing, most of them test dried poultry manure and superphosphate and two test sulphate of potash. There are figures for the individual pickings, usually carried out on three occasions, but sometimes on four, and in most cases there are figures relating to the proportion of blown or unsaleable sprouts. The mean yields of total saleable sprouts and the increases for the various nutrients are set out in Table I. In this and succeeding Tables the single dressings of sulphate of ammonia (N_1) and dried poultry manure (M_1) were usually at the rate of 0.3-0.4 cwt. N per acre, the double dressings N_2 and M_2 being 0.6-0.8 cwt. N. Superphosphate (P) was at the rate of 0.4-0.6 cwt. P_2O_5 per acre ; while sulphate of potash K_1 was at the rate of 1.0 cwt. K_2O per acre, K_2 being 1.5-2.0 cwt. K_2O.

The mean yields ranged from 22.4 to 90.8 cwt. of saleable sprouts per acre with a general mean of 44.3 cwt. The most marked manurial effect was given by nitrogen. For the years 1933 and 1934 there are sufficient centres to make an estimate of the average effect of this nutrient in the form of sulphate of ammonia and poultry manure, the results being brought to a common basis of 0.6 cwt. N per acre. The figures are :—

Total Saleable Sprouts, cwt. per acre.

Mean increase for 0.6 cwt. N per acre.

	No. of Experiments	Sulphate of Ammonia.	Poultry Manure.
1933.. ..	6	+1.65	+2.74
1934.. ..	4	+12.95	+7.46

TABLE I.

Brussels Sprouts. Total saleable Sprouts, cwt. per acre.

Year.	Centre No.	Soil.	Mean Yield.	Increases for N_1	N_2	M_1	M_2	P	K_1	K_2	Standard Error.
1931	1	Light chalk ..	49.3	−2.4	−0.9	+5.8	—	—	—	—	±3.44
1933	2	Clay loam ..	29.8	−0.3(1)	−1.4(1)	—	+1.2	+2.2	—	—	±1.24
1933	3	Sandy ..	40.4	—	+9.0	—	+4.8	−1.9	—	—	±1.89
1933	4	Chalk loam ..	22.4	−3.0	−5.7	—	−1.7	—	—	—	±1.84
1933	5	Poor sand ..	24.7	+1.2	—	+0.4	—	+0.3	—	—	±1.44
1933	6	Boulder clay ..	40.3	—	+2.0	—	+8.2	+10.3	—	—	±1.09
1933	7	Medium-heavy	38.3	+1.1	—	—	—	−0.2	—	+9.7	±1.28
1934	8	Clay loam ..	90.8	+3.9	+10.2	+9.0	+8.2	—	—	—	±2.60
1934	9	Silty gravel ..	63.9	+11.6	+16.3	+4.4	+7.6	—	—	—	±1.53
1934	10	Gravel loam	43.2	+13.1	+20.9	+3.7	+8.2	—	—	—	±1.00
1934	11	Gravel loam	58.7	—	+10.2	—	—	−3.7	+1.6(2)	+4.2(2)	±2.10
1935	12	Silty loam ..	29.8	+3.9	+2.4	+3.2	+4.8	—	—	—	±2.95

(1) ±1.53. (2) ±2.56.

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Responses were much greater in 1934 than in 1933, and in the more favourable season there is evidence that sulphate of ammonia was more effective than poultry manure providing the same amount of nitrogen. Thus at centres 9 (Wyboston, Bedfordshire), and 10 (St. Albans), the difference between sulphate of ammonia and poultry manure was significant.

The action of superphosphate was less general than that of nitrogen and only at one centre, No. 6 (Honeydon, Bedfordshire), on a boulder clay soil was its effect really important. In this experiment, however, 3 cwt. of superphosphate increased the yield by no less than 10.3 cwt., and it is probable that the superiority of poultry manure over sulphate of ammonia shown at this centre was due in part to the phosphate that the organic manure provided. There is some evidence of a beneficial effect of superphosphate on the heavy soil at centre 2 (Rothamsted).

Potash was tried at two centres only. At centre 7 (London Colney, Herts.) it gave the large increase of 9.7 cwt. for 3 cwt. of the fertiliser. In the following year at the same centre a smaller but nevertheless significant effect was obtained.

Earliness is a valuable feature in growing market garden crops and it is therefore important to trace the fertiliser effects through the successive pickings whose sum goes to make the total discussed above. The results are collected in Table II, which presents those centres at which the fertiliser responses were strongly defined. The total response in saleable sprouts is taken as 100 and the respective contributions of the separate pickings are expressed on this basis. The figures refer to the higher level of nutrient in each case.

TABLE II.

Saleable Sprouts.

Fertiliser responses in successive pickings.

Total response = 100.

Centre No.	Nitrogen. Pickings. 1st	2nd	3rd	Poultry Manure. Pickings. 1st	2nd	3rd	4th	Phosphate Pickings. 1st	2nd	3rd	4th	Potash Pickings. 1st	2nd	3rd	4th
1				+91	+31	−22									
2								+88	−19	+13	+18				
3	+77	+13	+10	+80	+14	+6									
6				+19	+35	+29	+17	+39	+34	+20	+7				
7												+28	+43	+20	+9
8	+8	+80	+12	−9	+97	+12									
9	+20	+58	+22	+30	+40	+30									
10	+82	+7	+11	+60	+30	+10									
11	+51	+33	+16									+196	−60	−36	

In the above table there are 15 results showing three or more pickings. In nine instances the response in the first picking is the greatest, and in six of them over three-quarters of the total effect is to be found in the first picking. In the six experiments in which the first picking is not greatest the second picking is the largest. In no case is there more than 30 per cent. of the total response in the third picking, or 18 per cent. in the fourth. In several of the experiments the predominance of the fertiliser effect in the first picking is in itself significant, e.g., at centre 2 (Rothamsted) and 11, (London Colney). The figures show that when a nutrient is effective, its action tends to be strongest in the early part of the season. Phosphate and potash both gave earlier crops at each of the two centres where they acted. Sulphate of ammonia and poultry manure, on the other hand, did not appear to hasten growth.

The experiments give some information on the relationship of fertiliser action and grade of produce for in most of them the weight of " blown " or unsaleable sprouts was ascertained, and in some of them the saleable sprouts were themselves graded. The effects of the nitrogenous manures on the weight of " blown " or unsaleable sprouts and their percentage of the total crop, including blown are given in Table III.

TABLE III.

Effects of nitrogenous manures on blown (or unsaleable) Sprouts expressed as increases over controls.

Centre No.	Increases cwt. per acre				Per cent. of total crop.			
	N_1	N_2	M_1	M_2	N_1	N_2	M_1	M_2
1	+3.0	+4.5	+6.5	—	+4.5	+5.5	+5.0	—
2	+0.2	+0.2	—	+1.1	+0.3	+1.3	—	+1.6
3	—	+2.1	—	+0.9	—	+1.6	—	+0.6
4	−0.5	−1.0	—	+0.5	−1.1	+2.7	—	+2.4
5	+2.0	—	+0.8	—	+4.3	—	+1.6	—
6	—	+1.2	—	+0.6	—	+1.5	—	−1.7
7	+0.5	—	—	—	+0.6	—	—	—
9	+1.1	+1.9	+1.3	+2.0	+1.0	+1.7	+1.6	+2.7
10	+0.8	+1.2	+0.2	+0.4	−1.7	−2.4	−0.7	−1.3

In eight of the nine experiments with sulphate of ammonia the actual weight of unsaleable sprouts per acre was increased, by an average of 1.4 cwt. per 3 cwt. sulphate of ammonia. The percentage of unsaleable produced was also increased in eight out of the nine experiments. At centre 10 (Oaklands), St. Albans, the effect of nitrogen on yield was so large that although the actual quantity of blown sprouts was increased, the percentage was smaller. Dried poultry manure behaved similarly to sulphate of ammonia at most centres. The effect of superphosphate was in general small, but at centre 6 (Honeydon, Bedfordshire), the unsaleable sprouts were increased by 1.6 cwt, while the percentage unsaleable was decreased by 0.6 per cent. In one experiment with potash the actual yield of unsaleable sprouts was increased by 1.3 cwt. but the percentage fell by 1.1. per cent. Taking the results as a whole, the effect of manures appears to be slightly to increase the actual weight of blown or unsaleable sprouts, but when the crop responds well to manures the final result is that the proportion of unsaleable produce is reduced.

Six experiments, set out in summary form in Table IV, are on record dealing with cabbages and Broccoli.

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TABLE IV

Cabbages and Broccoli

Effect of Nitrogen, Phosphate and Potash

Weights or numbers per acre

Crop	Centre No.	Soil	Mean Yield Tons or Numbers	Increase for N_1	N_2	M_1	M_2	P_1	P_2	K†	Standard Error
Spring Cabbage	1	Light	13.6	+1.19	—	—	—	—	—	+0.43	±0.496
Spring Cabbage	2	Sandy	6.0	+1.17	+2.87	+0.65	+0.96	—	—	—	±0.838
Savoys	3	Medium	20.6	—	+7.42	—	+3.94	—	—	—	±1.270
Broccoli Heads	4	Shale loam	1.56	—	+0.22	—	+0.16[1]	−0.03	—	—	±0.097
Broccoli Outsides	4	Shale loam	7.28	—	+0.68	—	+0 48[2]	+0.02	—	—	±0.437
Number	4	Shale loam	5,838	—	+303	—	+100[3]	−49	—	—	±133
Winter Cabbage	5	Sandy	5,462	+510	+1,245	—	—	—	—	—	±350
Winter Cabbage	6	Sandy	2,727	—	—	—	—	+281	+360	—	±259
Wt. per Cabbage, lb.	—	—	1.25	—	—	—	—	—	0.0	−0.02	±0.038

(1) S.E. ±0.119. (2) S.E. ±0.536. (3) S.E. ±163.
†K stands for 1·3 cwt. K_2O per acre, as Sulphate of Potash.

Spring cabbages respond well to nitrogen as sulphate of ammonia at centre 1 (Avoncroft, Evesham) and 2 (Steppingley, Bedfordshire). At Steppingley, there is some indication that sulphate of ammonia was more effective than dried poultry manure but the difference does not reach significance. Savoy cabbages at centre 3 (Newport, Salop) show strong nitrogen responses and here the difference between sulphate of ammonia and poultry manure is statistically significant. At centre 4 (Dartington Hall, Devon) sulphate of ammonia increased the yield of broccoli heads and also the number per acre, the effect of dried poultry manure was smaller. At centre 5 (Potton, Beds.) nitrate of soda, applied to the previous early potatoes in this case, significantly increased the number of cabbages fit to cut on December 7th. There were no marked effects of phosphate or potash in the above experiments, and so far as they go they support the view that quick-acting nitrogen is likely to prove the most useful fertiliser for this type of crop.

The results for first early potatoes and root crops have been summarised in Table V. The figures for first early potatoes have been derived from a single farm, Potton, Beds., in 1931 and 1934. Experiments 1 and 2 were without dung; experiment 3 received dung. The crop was lifted early and proved very unresponsive in all cases. It is known from other experiments that first earlies left to stand till later in the season respond better to manures. Thus a crop at Little Downham, Ely, on fenland soil cut down by frost on May 17th, 1935, and left to stand till July 30th, gave an increase of 3.03 tons for 5 cwt. of sulphate of ammonia and 1.43 tons for 3 cwt. superphosphate per acre, both significant.

With the exception of a significant increase for poultry manure at centre 4 (Wye) and an improvement in the proportion of first grade bulbs at 7 (Swanley), onions have shown little response to nitrogen or phosphate in these experiments. Carrots have been surprisingly unresponsive in the roots; sulphate of ammonia and poultry manure generally reduced the yield and at centre 9 (Chittoe, Wilts.), the reduction was almost significant. Sulphate of ammonia increased the tops significantly at 10 (Woburn) and worked in the same direction at a second experiment at Woburn, 9. Plant number is significantly reduced by sulphate of ammonia in experiment 10. The very large yield in experiment 8 was the result of a dunged bare fallow in the previous year.

Red beet shows a good and significant response to sulphate of ammonia but less to dried poultry manure. The difference between the two manures although in the usual direction is not significant.

TABLE V
First Early Potatoes and Root Crops
Effect of Fertilisers

Centre No.	Soil	Mean Yield	Increase for N_1	N_2	M_1	M_2	P_1	P_2	K_1	Standard Error
First Early Potatoes		Tons								
1	Sandy	4.71	+0.14	+0.32	—	—	—	—	—	±0.170
2	Sandy	4.02	—	—	—	—	+0.25	−0.21	—	±0.175
3	Sandy	3.78	—	—	—	—	+0.14	—	+0.06	±0.124
Onions										
4	Chalk loam	7.64	—	+0.09	—	+0.86	+0.11	—	—	±0.332
5	Light	11.23	—	−0.06	—	+0.11	—	—	—	±0.452
6	Light	10.15	—	+0.03	—	+0.30	—	—	—	±0.407
7	Sandy	6.07	—	−0.25	—	+0.79	—	—	—	±0.691
		Per cent. 1st grade 66.4	—	+6.9	—	+6.0	—	—	—	±3.03
Carrots										
8	Sandy	Tons								
	roots	21.10	−1.20	−0.54	−0.20	−0.32	—	—	—	±0.722
	tops	9.23	+0.23	+0.94	−0.41	+0.57	—	—	—	±0.551
9	Sandy roots	10.52	—	−1.02	—	−0.77	—	—	—	±0.491
10	Sandy									
	roots	8.97	—	−0.63	—	+0.16	—	—	—	±0.421
	tops	3.42	—	+0.62	—	+0.29	—	—	—	±0.199
	Plant No.	Thous. 106.1	—	−5.0	—	−1.4	—	—	—	±1.422
Red Beet		Tons								
11	Loam	14.72	—	+2.10	—	+0.88	—	—	—	±0.800

Turning now to leguminous crops there have been five experiments on peas, one on French beans, and one on Runner beans. The results are summarised in Table VI.

TABLE VI
Leguminous Crops.

Year	Centre No.	Soil	Mean Yield per acre	Increase for N	M	P	K	Standard Error
Peas								
1933 ..	1	Sandy gravel	Peas cwt. 34.3	+3.50	—	−0.70	−2.45	±1.00
1934 ..	2	Light loam	,, ,, 77.0	+4.0	−1.2	—	—	±2.35
1934 ..	3	Sandy clay	,, ,, 46.8	−1.2	+5.4	—	—	±4.44
1934 ..	4	Silty gravel	,, ,, 93.9	−3.6	−4.1	—	—	±1.84
1934 ..			Haulm ,, 76.5	+2.9	−2.9	—	—	±1.37
1935 ..	5	Medium Loam	Peas ,, 96.7	−9.9	−4.3	—	—	±5.80
French Beans								
1935 ..	6	Sandy	Beans cwt. 45.1	+0.7	+9.4	—	—	±3.27
			Haulm ,, 61.6	+12.2	+29.8	—	—	±4.64
Runner Beans								
1935 ..	7	Alluvium	Beans ,, 39.7	+4.7	+5.0	—	—	±5.88

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Peas have given very different results at the different centres. No. 1 (Stanford, Beds.) gave a significant response to quick-acting nitrogen, and the average response at centre 2 (Evesham) to sulphate of ammonia both in presence and in absence of poultry manure was $+4.9 \pm 1.66$ and therefore significant. On the other hand nitrogen in general reduced the yield significantly at centre 4 (Langford, Beds.), the effect was in the same direction also at 5 (Norton, Yorks.).

On French beans at 6 (Godalming) there was some indication of a response to poultry manure but none to sulphate of ammonia. Both manures give marked increases in haulm at this centre and in this respect poultry manure was significantly more effective than sulphate of ammonia. There were no effects on runner beans.

In experiment 1, phosphate in the form of basic slag had no effect on peas at Stanford, whereas potash significantly depressed the crop—an unexpected result on a sandy soil.

Experiments on miscellaneous horticultural crops have included lettuces, strawberries, celery, and apple stocks grown for vegetative reproduction. None of the manures tried had any effect on the number of lettuces fit to cut in spring ; in fact, their action was slightly depressing but not to a statistically significant extent. Manures applied to the parent apple stock in mid-June had no effect in the value of the offshoots, although sulphate of ammonia significantly reduced the value of the roots borne by the offshoots. It is possible that earlier application of fertilisers might have given better results.

Sulphate of ammonia was compared with poultry manure on strawberries and while the quick-acting nitrogen tended to depress the weight of total crop, the organic manure tended slightly to increase it, the mean difference being almost significant. Effects in the same direction were observed in the percentage of first grade fruits so that the final result was :

LONG ASHTON, 1934

First Grade Strawberries cwt. per acre	
No nitrogen	5.91
Sulphate of Ammonia ..	4.30
Dried Poultry Manure ..	6.72

Celery proved to be a more responsive crop. The experiment at Mepal, Isle of Ely, on a light fenland soil in presence of farmyard manure showed definite increases in yield for superphosphate, sulphate of potash, and agricultural salt. Potash and salt also gave a significant improvement in the grading results. The figures relating to the above crops are given in Table VII.

The experiments summarised above give some information on the question of the relative precision of experiments on the vegetable crops as compared with ordinary farm crops. The average values for the standard error of a single plot expressed as a percentage of the mean yield have been determined by Yates*, for potatoes and sugar beet in recent randomised block and Latin square experiments at the outside centres, and these figures are given below together with general averages from all available Rothamsted experiments for swedes, mangolds and Kale.

*F. Yates, Suppt. Jn. Roy. Stat. Soc., 1935, 11p. 214.

TABLE VII

Miscellaneous Crops

Centre No.	Soil	Mean Yield per acre	N_1	N_2	M_1	M_2	P_1	P_2	K_1	K_2	Standard Error
Lettuces 1	Medium Loam	No. thous. 33.3	−6.0	−5.9	—	—	−2.3	−3.8	−1.5	−3.7	±3.28
Apple Stocks 2	Clay with flints	Value per stock, pence, 14.65	—	−0.48	—	—	+0.36	—	—	+0.10	±0.735
		Value of roots, pence, 0.92	—	−0.27	—	—	0.0	—	—	+0.08	±0.094
Strawberries 3	Medium Loam	Total cwt., 17.9	−2.8	−4.6	+1.5	+1.2	—	—	—	—	±2.65
		First grade %30.7	−4.90	−4.61	+3.09	+0.74	—	—	—	—	±2.61
Celery 4	Light Fen	Total tons, 8.32	Salt +0.43	—	—	—	—	+0.34	—	+0.89	±0.144
		Two Highest grades, %61.6	+3.9	—	—	—	—	−1.0	—	+4.0	±2.42

STANDARD ERRORS PER PLOT

Average Values as percentage of Mean Yields

	No. of Expts.	
Potatoes 1927-1933 Latin Square ..	56	6.8
,, ,, ,, Randomised blocks	22	9.2
Sugar Beet Roots Latin Squares ..	28	6.1
Randomised blocks	15	7.9
Swedes. Mean of all plot arrangements	8	6.9
Mangolds ,, ,, ,,	6	8.2
Kale .. .. ,,	18	7.7

These values are rather uniform and it appears that for ordinary farm roots standard errors of about 7 to 8 per cent. may be regarded as normal.

In Table VIII below are collected the actual and percentage standard errors per plot of the vegetable crops discussed above.

TABLE VIII

Standard Errors of Experiments on Vegetable Crops, **1931-1935**

(A) Full Sized Plots.

Crop	No. of Expts.	Standard Error per plot.	
		Actual per acre	Per cent of mean
Brussels Sprouts, total crop cwt.	11	3.83	10.1
Winter cabbages. No. fit to cut	2	518	13.2
Broccoli heads. Tons	1	0.29	18.6
Spring cabbages. Tons ..	2	1.04	12.1
Savoy cabbages. Tons ..	1	2.00	9.7
First Early potatoes. Tons ..	3	0.27	6.6
Carrots. Tons	3	1.08	8.7
Onions. Tons	4	0.92	11.9
Peas. Cwt.	4	4.02	7.5
Runner beans. Cwt.	1	11.76	29.6
Celery. Tons	1	0.35	4.3

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(B) Microplots (1/145 acre or less).

Crop	No. of Expts.	Standard Error per plot	
		Actual per acre	Per cent of mean
Tomatoes. Total crop, tons . .	2	2.96	5.6
Apple stocks. Value, pence per stock	1	2.94	20.0
Lettuce. No. fit to cut, thous.	1	9.86	29.6
Pyrethrum. Dry flower heads, cwt.	2	0.92	15.6
Peas. Cwt.	1	8.20	8.5
French beans. Cwt.	1	4.62	10.2
Red beet. Tons	1	1.13	7.6
Strawberries. Cwt.	1	5.3	29.6

The most reliable value in this table is that for sprouts, which rests on 11 experiments. With a mean standard error of 10.1 per cent., this crop is slightly more variable than ordinary farm roots, possibly owing to the much smaller plant population per plot and the element of judgment entering into the several pickings. Nevertheless, a standard error of this size would be regarded as quite normal for certain farm crops such as cereals. Among other crops, broccoli and runner beans stand out as rather variable, while early potatoes, carrots, and peas have given values quite in keeping with those derived from ordinary potatoes and roots.

As might be expected the microplots show somewhat larger errors. The actual magnitude of the standard errors is the important figure for estimating the size, or cash value, of a difference that is likely to be detected by experiments of the kind under review. A well-designed experiment set out as a 6 by 6 Latin square will detect, as statistically significant, differences between treatment means of almost three-quarters of the standard error per plot. Smaller arrangements are less precise. The size and value of differences that would be judged significant in experiments of the precision of the Latin square are :—

Significant Differences per Acre

	Actual size. Cwt.	Approximate cash value. Shillings
Brussels Sprouts	2.7	34
Carrots	15	97
Onions	13	80
Peas	2.8	44

It is clear that the value of produce represented by a significant difference is quite large in relation to any probable expenditure on manures, so that with these high value crops the most efficient arrangements and fullest replication possible should be aimed at, so that treatment effects that are actually of high cash value and well worth having shall not fail to reach the level of statistical significance.

EFFECTIVENESS OF FERTILISERS

Our experiments show certain consistent differences between the three main groups of fertilisers. Nitrogenous fertilisers nearly always increase plant growth, though in many cases they produce their full effect only when potash and phosphates are also supplied. It is not usually possible to say beforehand whether these will be necessary or not ; soil analysis reveals the extreme cases of poverty but often fails to show the requirements on ordinary good farms. The effectiveness of potash and phosphate depends much more on soil and season than does that of nitrogen ; in 1935 some of the responses to potash were very marked, while others were not :

Comparison of Potash Response of Different Crops in 1935

				Mean Yield	Increase per 1.0 cwt. K_2O	% Increase
Six course rotation	Sugar beet.	Roots.	Tons	8.56	−0.24	−2.8
		Tops	,,	9.05	−1.55	−1.7
	Barley	Grain.	Cwt.	37.1	0.7	1.9
		Straw	,,	45.2	1.2	2.6
	Wheat	Grain	,,	25.3	3.2	12.6
		Straw	,,	42.0	6.2	14.8
	Potatoes		Tons	6.75	1.08	16.0
	Beans		Cwt.	21.0	2.7	12.9

Superphosphate was less effective than potash in 1935. Many experiments show that potash or phosphate can in certain seasons be omitted from the fertiliser without loss of crop, the necessary food being taken from the soil. But this process cannot be continued indefinitely ; if phosphate or potash starvation sets in it seriously reduces yields of important and expensive crops like potatoes. There may be times when the stored up fertility of the soil can be drawn upon and converted into cash, but as a regular procedure this may soon have undesirable effects. Now that rotations are not so strictly followed as before and farmyard manure is less readily obtainable it becomes important to watch the manuring closely and ensure that ample dressings are given for full crops and for maintaining the productiveness of the land.

MECHANISED CULTIVATION OF GRAIN CROPS

Problems arising out of the mechanised cultivation of arable land continue to receive attention. Both at Rothamsted and at Woburn deterioration of yield has followed from long continued growth of cereals on the same land where only artificial fertilisers are used, but the yields have been better maintained with farmyard manure. On modern mechanised farms and market gardens, little or no farmyard manure is made and therefore organic manure must either be brought in from outside or more or less dispensed with. For cereal growing it is not yet clear that this will matter very much for a few years, and good yields have been obtained without farmyard manure by suitable additions of artificial fertilisers, by occasional fallows and clover leys. For root crops, potatoes, sugar beet, for market garden crops and in some circumstances apparently for clover and lucerne, farmyard manure has special beneficial effects not easily obtained otherwise. Also on the lighter soils, such as those on which mechanisation is likely to be practised, the supply of organic manure is very important even for cereal growing. Two methods are being tried for increasing the supply of organic manure on the farm : green manuring and the return of straw to the land. The former is an old device, but very uncertain in its operation. The latter can be accomplished in various ways, several of which are being studied :

(*a*) Straw is being rotted in heaps by addition of the necessary nutrients for the micro-organisms ; this involves the difficulty of adequately moistening the heap.

(*b*) Straw is spread over the ground and ploughed in, the necessary artificial fertilisers being added either with the straw or later when they are likely to be most effectively used by the following crops. This method is being tried also at Sprowston on the farm of the Norfolk Agricultural Station.

In the Fermentation Department much work is done on the rotting of straw and other vegetable products to produce a good manure. This work continues to attract considerable attention, and workers come from overseas to study the possibilities of products available to them ; an Indian worker, Dr. Acharya, has in 1935 been investigating the rotting of rice straw. Organic manures, so far as they have been tested, have, however, less fertiliser value than the equivalent dressings of inorganic fertilisers.

Neither at Rothamsted, Woburn, nor on Mr. Prout's farm at Sawbridgeworth, were diseases or pests important, even after many years of continuous wheat growing. But in 1935 complaints reached us from mechanised farms of serious disease trouble even after 3 or 4 years only of wheat growing. Mr. Samuel found that the trouble was due to Take-all (*Ophiobolus*) or to *Fusarium*. By a curious coincidence, none of the three classical continuous wheat fields is liable to these diseases (though Take-all appeared at Woburn near the end of the experiment), but the light chalky soils on which mechanisation is developing are more susceptible to them. Mr. Samuel is taking up this question in detail.

Fallowing is, however, very effective in restoring productiveness to land deteriorated by continuous cultivation, though it is only temporarily beneficial. In general it makes a better preparation for wheat than clover or temporary leys. Unfortunately, fallowing favours the Wheat bulb fly (*Hylemyia coarctata*), and at the time of writing (May, 1936) the wheat crops sown after the fallows of 1935 are looking worse than any on the farm as the result of attacks by this insect, aggravated no doubt by heavy losses of soil nitrates during the very wet winter. Methods of control are being sought.

An important effect of fallowing is to keep down weeds and Dr. Brenchley has spent much time in discovering the conditions under which this is best done for the more important species. Chemi-

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cal spraying methods are also being tried, and a series of experiments has been started, with quite interesting results so far, on the possibility of removing weeds from grassland by spraying.

SOIL CULTIVATION

The cultivation experiments have continued, and an extensive series of observations on rotary cultivation is being worked up.

Soil tilth has been studied from the field side in Dr. Keen's cultivation experiments and from the laboratory side by him and his assistants, Mr. Scott Blair, Mr. Cashen and Dr. E. W. Russell. The essential point is to bring the soil into an aggregation of crumbs and to prevent it falling into a state of dust. The actual changes depend on the drying and re-wetting of the soil and are brought about largely by the weather, but the implements play a vital part in putting the soil into such form that the weather can act. The field experiments have shown some of the differences between rotary cultivation and the older methods. They are now being extended to show how the soil moisture is affected by the various cultivation processes : this work is difficult because the Rothamsted soil, by its stony nature, is not readily sampled, and no method of estimating the moisture content *in situ* is yet free from objection.

The laboratory work has now reached a stage where the numerous facts are falling into order. An important test of value of any new development is the extent to which it can be used. These physical investigations have already proved of value to experts concerned with such diverse industries as flour milling and oil boring apart from their use in agriculture.

MINOR ELEMENTS IN PLANT NUTRITION

In 1923 Miss Warington proved definitely for the first time that a minute quantity of boron is essential for plant growth, and this result has already found applications in practice. Various crop diseases previously incurable have now been traced to a lack of available boron ; notably a heart rot in sugar beet and " Internal cork " in apples in New Zealand, " Top rot " of tobacco, and diseases of potatoes, turnips, tomatoes and other crops. These diseases may occur even when compounds of boron occur in the soil, but presumably the boron is unavailable, because they are cured by addition of a small quantity of borax. The subject is being further developed and several field experiments on sugar beet have been started in affected areas in consultation with us.

It is known that oats suffer from shortage of manganese on certain soil types, and the factors controlling the availability of the manganese in soils are being studied.

Small amounts of molybdenum salts are also shown to affect plant growth considerably, causing, in some cases, simulation of

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the symptoms of virus disease, and in others, the development of a trailing habit of growth where normally the growth is upright. These results are being further studied.

The effects of small quantities of nickel and cobalt salts are also being investigated.

COMPOSITION AND QUALITY OF CROPS

Owing to the impossibility of finding as yet any valid definition of quality, this work is done in association with the expert users of the crop, and their marks or grades, which are really measures of "commercial desirability," are accepted as the nearest measure of quality we are likely to get for the present. The buyers' grades have objective reality, for when the crop is converted into food, the resulting products show differences which vary in the same direction as the grades. So far as human food is concerned, we do not proceed to ascertain the physiological significance of these differences, but for animal food something can be done, though not yet as much as we should like because no satisfactory technique for grazing experiments in the field has yet been worked out. A beginning has been made, however, with experiments on pigs fed in pens.

The crops most investigated have been barley, potatoes, sugar beet and grass; and the expert bodies associated with the work were respectively the Institute of Brewing, Messrs. Lyons, the Beet Sugar Factory organisations, and the Basic Slag Committee of the Ministry of Agriculture. For the arable crops, the general result is that fertilisers used in the normal way will commonly increase the yields but do not affect the quality. Potassic fertilisers may effect some improvement in quality of crops grown for carbohydrates, and excessive dressings of nitrogenous fertilisers may reduce their quality. Beyond this there is no evidence that any system of manuring will bring about any significant improvement in the quality. For this the most important factors are the soil type and the season, and they have been fairly well characterised for barley. The conditions are unchecked growth, ample moisture during the spring, dry summers and good ripening and harvest conditions. For other crops the conditions are not yet so clearly defined, but it is known that suitable moisture supply and soil aeration are important.

Wheat

The technical applications of the earlier work on the physics of flour doughs have been extended by Mr. Scott Blair in co-operation with Dr. Halton of the Research Association of British Flour Millers at St. Albans. The aim of this investigation is to assess the bread-making quality of a flour by means of reproducible and impersonal tests on the dough. Hitherto the only test of quality has been the baking test, and this, even in the hands of a highly skilled baker, is subjective and unreliable.

The two most important properties required of a dough are adequate elasticity ("spring") and extensibility. The former

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depends on an optimum relationship between viscosity and elasticity modulus, and the latter, although not yet fully understood, is related to the way in which viscosity varies with stress. The bearing of these properties on bread making quality is being investigated. Doughs which tear easily, and consequently give bread with ragged crust and bad texture, are said to be "short." This property of "shortness," and the relationships between the breaking and the flowing of plastic materials, are being studied. Brittleness, which is disadvantageous in the flour-dough, is beneficial in the soil crumb, and the methods developed for the study of the dough are now being modified for application to the soil. The same principles are being applied at the National Dairy Institute for measuring the elastic and plastic properties of cheeses.

Flour doughs show a definite structure which is broken down on kneading, and re-establishes itself on standing. This property is fairly common and is called "thixotropy" (see also p. 64).

THE BIOCHEMISTRY SECTION 1933-1935

A. G. NORMAN

The work of this section consists in a study of the composition and decomposition of plant constituents, particular attention being given for the present to the carbohydrates.

METHODS OF ANALYSIS OF PLANTS

The conventional methods of analysis of agricultural materials give a very imperfect picture of the composition of a plant, being restricted usually to such determinations as ash, total nitrogen, (calculated as crude protein), ether-soluble material, and crude fibre, the difference of the sum of these from 100 being regarded as "soluble carbohydrates." Before any extended study of the composition of crops could be attempted, a more detailed and searching system of analyses had to be found to cover the carbohydrate constituents. This involved particularly the testing of methods for the determination of those structural constituents which are most inadequately represented by the crude fibre figures. The main structural constituents, cellulose, lignin and hemicelluloses, together account for the major part of any mature tissue. Existing methods have not been found to be generally applicable without modification.

1. *Cellulose.* The cellulosic framework of plant tissues is determined after removal of all other constituents. In fact, however, lignin is the most difficult component to remove. The Cross and Bevan procedure of alternate exposure to gaseous chlorine and extraction with boiling sodium sulphite is the basis of nearly all methods, the lignin thereby passing into solution as sulphonic derivatives. The conditions under which the chlorination may be carried out in dilute hypochlorite solution, have been examined,

and a more rapid and convenient method developed (1). The cellulose of plants and wood differs from that of the cotton hair in that it is not solely composed of glucose units, but contains also polysaccharides of other sugars, very intimately associated. These polysaccharides, which have been termed "cellulosans" (2) are more susceptible to hydrolytic agents, and more soluble in alkalis, than the true cellulose portion of the aggregate, so that all treatments other than with neutral solutions must be avoided if the integrity of the natural cellulose is to be preserved. The method devised is also suitable for making large-scale preparations of plant celluloses which was not possible previously. In most cases the associated cellulosan is xylan, which may be determined by the yield of furfuraldehyde from the isolated cellulose.

2. *Lignin.* The basis of the determination of lignin is the resistance of this substance to strong acids, in which cellulose and other carbohydrates pass into solution, subsequently to be hydrolysed. Existing methods, devised mainly for woods, have been shown to be inaccurate and quite inapplicable to agricultural materials, which unlike woods are often high in nitrogen. Two major and interacting sources of error have been shown to exist, due to the presence of pentoses and proteins. Pentoses or pentosans on contact with strong acids slowly give furfuraldehyde which in the absence of lignin condenses to form a black insoluble residue weighed as lignin (3) or in the presence of lignin unites with it to give a stable ligno-furfuran resin, thereby increasing the apparent lignin content. This disturbance may be minimised by shortening the period of contact with the strong acid, or by a hydrolytic pre-treatment (4). The error introduced by the presence of protein is at present more obscure and has not been wholly overcome. Proteins themselves or protein degradation products give no residue on treatment with strong acid but if added to a lignified material increase the apparent lignin content (5). Small quantities of protein cause a greater disturbance proportionately than do larger amounts, the error being due to the linkage with lignin of protein fission products of varying size. Acid pre-treatment results in a substantial reduction of the interference in most cases, which cannot be allowed for by calculating the nitrogen content of the lignin residue as protein and deducting. Because of these sources of error in the lignin determination the figures generally quoted for the lignin content of plant materials are in most cases too high.

3. *Hemicelluloses.* A satisfactory method for the routine determination of hemicelluloses has not yet been devised. Extraction methods that have been proposed are incapable of distinguishing between the true encrusting polyuronide hemicelluloses, and the cellulosan fraction of the cellulose, which has very similar properties.

(1) A. G. Norman and S. H. Jenkins—"A New Method for the Determination of Cellulose based upon Observations on the Removal of Lignin and other Encrusting Materials." Biochem. Journ., 1933, Vol. XXVII, pp. 818-831.

(2) L. F. Hawley and A. G. Norman—"The Differentiation of Hemicelluloses." Ind. and Eng. Chem., 1932, Vol. XXIV, pp. 1190-1195.

(3) A. G. Norman and S. H. Jenkins—"Lignin Content of Cellulose Products." Nature, 1933, Vol. CXXXI, p. 729.

(4) A. G. Norman and S. H. Jenkins—"The Determination of Lignin, I. Errors introduced by the Presence of Certain Carbohydrates." Biochem. Journ., 1934, Vol. XXVIII, pp. 2147-2159.

(5) A. G. Norman and S. H. Jenkins—"The Determination of Lignin, II. Errors Introduced by the Presence of Proteins." Biochem. Journ., 1934, Vol. XXVIII, pp. 2160-2168.

For the present and for comparative purposes, reliance is placed upon the yield of furfuraldehyde from the pentose and uronic acid groupings as a measure of the amount of encrusting hemicelluloses, this figure being arrived at by the difference between the total furfuraldehyde yield and that from the cellulosan groups in the cellulose.

The analyses mentioned above taken together provide a full picture of the structural constituents of any plant material and permit a detailed examination of the "crude fibre" determination, so much employed in agricultural analysis; by their aid it has been possible to show what exactly this fraction represents(6). The crude fibre figure may be very misleading since no constant or definite proportions of the structural constituents are included. The cellulose is partially attacked so that only 60 to 80 per cent. remains, and the lignin extensively removed by the acid and alkaline treatments given. Much variation may be found in the lignin content of crude fibre fractions. Since the presence of lignin exercises a direct effect on the digestibility of the material, any empirical method should include all the lignin. For certain purposes a simple acid hydrolysis would supply more reliable information than the crude fibre determination.

The Composition of Crops

Suitable methods having been devised a study of the composition of certain crop materials was commenced along the lines of a preliminary investigation carried out in 1930 on barley(7). Samples are cut at frequent intervals during growth so that the developmental changes may be followed. So far the investigations have been confined to winter wheat, and rye grass (Western wolths). The latter revealed several interesting features which are to be the subject of future examination. A high percentage of cold water-soluble material was found in this grass, at one stage nearly 55 per cent., and at maturity almost 40 per cent., the bulk of which is accounted for by a fructosan, or levan. At one stage the fructosan content was found to be 35 per cent. but as the grass approached maturity the amount of this constituent fell sharply while at the same time the cellulose increased. Neither the protein nor the lignin contents changed as widely as expected, and it is clear that a relatively small change in the amount of lignin present is responsible for the considerable decrease in digestibility that accompanies maturity. On drying for hay in the usual manner, the losses appeared to be of the order of 10 to 15 per cent., much of which could be accounted for by the disappearance of fructosan. Preparations of this fructosan have been found to be more susceptible to acid hydrolysis than any other polysaccharide, being completely broken down to fructose by heating with oxalic acid as dilute as 0.05 per

(6) A. G. Norman—"The Composition of Crude Fibre." Journ. Agric. Sci., 1935, Vol. XXIV pp. 529-540.

(7) A. G. Norman—"A Preliminary Investigation of the Development of Structural Constituents in the Barley Plant." Journ. Agri. Sci., 1933, Vol. XXIII, pp. 216-227.

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cent. for one hour. Fructosans have also been found in wheat, though not to such an extent; apparently they have an important rôle in the metabolism of the Gramineae as a temporary carbohydrate reserve.

THE PLANT CELL-WALL

Accompanying these applied studies of plant composition, some more fundamental work on the nature and inter-relationship of the cell-wall constituents has been undertaken, mainly on cereal straws and fibre plants.

1. *Cellulose.* It has been stated before that most plant celluloses are very different from cotton cellulose in that they are aggregates of pure cellulose and an associated polysaccharide or cellulosan, which is often xylan. Many plant celluloses have been isolated and their properties and stability studied with a view to obtaining information as to the method of association of the cellulosan, and its influence on the properties of the whole. The results are not inconsistent with the view that the cellulosan molecules, though much shorter in length, are oriented like the long cellulose chains and participate in the micellae, being retained by the same type of secondary valency forces. Heat drying liberates a water-soluble fraction, mainly of cellulosan, from a natural cellulose previously unaffected by water, and this phenomenon may be repeated many times. Any attack on the cellulosan such as acid hydrolysis or alkaline extraction is accompanied by a partial attack on the cellulose so that no hard and fast line can be drawn between the two groups. Solution and reprecipitation from a cellulose solvent, by destroying the orientation of the molecules, renders the cellulosans easily soluble. To obtain additional evidence on the distribution of the xylan in such celluloses, experiments have been carried out on certain vegetable fibres in conjunction with Mr. W. T. Astbury, of the University of Leeds, using X-ray methods. The removal of xylan progressively from manilla hemp cellulose was accompanied by an improvement in the X-ray picture indicating a more perfect crystallographical state. When freed from xylan, the diagram was almost indistinguishable from those of ramie and Italian hemp, both celluloses which are naturally very low in xylan (8). The diagram for isolated xylan has also been obtained by the preparation of thin films. The X-ray evidence is in accord with the view that the xylan molecules are iso-structural with those of the true cellulose chains.

In a study of the composition of vegetable fibres of many types, it was found that these fall into two well-defined groups according to whether the cellulose of the fibre was high or very low in xylan. (9) The group high in xylan includes the coarser fibres, such as jute, manilla hemp, and sisal, all of which contain also appreciable amounts of lignin and encrusting substances. The second group, low in xylan, includes the high-grade fibres such as flax,

(8) W. T. Astbury, R. D. Preston and A. G. Norman—" X-Ray Examination of the Effect of Removing Non-Cellulosic Constituents from Vegetable Fibres." Nature, 1935, Vol. CXXXVI, p. 391.

(9) A. G. Norman—" The Composition of some Vegetable Fibres, with particular reference to Jute." Biochem. Journ., 1936, Vol. XXX (in the press).

ramie and hemp. No direct relationship between xylan content and quality could be found in a wide range of jute samples.

2. *Lignin.* Arising out of the observation reported previously that lignin condenses with furfuraldehyde in the presence of strong acid, to give a complex of the nature of a phenolic resin, similar resins with a number of other aldehydes have been prepared. Imperial Chemical Industries have moulded the lignin-formaldehyde resin under high pressure. Phenol may further be condensed with the lignin-aldehyde complex with a resulting modification of properties. Lignin resins with acetaldehyde or higher aldehydes have not yet been tested commercially.

Considerable attention has been given to the delignification of plant materials by means of solvents. For many research purposes it would be desirable to achieve a complete removal of lignin without at the same time bringing about hydrolysis or degradation of the carbohydrates. Solvents such as pyridine, dioxan, alcohol, etc., have been tried, with, and without, previous chlorination, but so far only partial success has been achieved. The removal of lignin with alcoholic soda has been investigated since this has been proposed as a pretreatment to the preparation of the hemicelluloses, but neither cold nor hot is this an effective delignifying agent.[10]

3. *Hemicelluloses.* The encrusting polyuronide hemicelluloses are an important group in many agricultural materials; in straw, for example, they form the second largest constituent. The study of their composition is beset with difficulties, and all preparations are more or less seriously contaminated with lignin and cellulosan. To reduce the former, it has been customary to effect a partial delignification with alcoholic soda, but this has been shown to have at the same time a serious effect on the hemicelluloses, and particularly on those of immature tissues.[10] A study of the removal of lignin and hemicelluloses from the cell-wall by alternate chlorination and sulphite extraction has thrown some light on the condition of the hemicelluloses *in situ.*[11] It seems likely that there is some form of close association, probably amounting to actual chemical combination, between the hemicelluloses and lignin, since the former cannot be extracted unless a pretreatment (such as chlorination) is given capable of rupturing the linkage, or unless a solvent (such as alkali) is used which at the same time dissolves the lignin. The classical conception of the existence of a " lignocellulose " has had to be abandoned in view of modern work on the structure of cellulose, and it now appears that a lignin-hemicellulose complex may be substituted for it. Possibly both groups occur in two conditions, combined and free.

Decomposition of Plant Materials

The limitations of the lignin determination now being understood, it was thought worth while to take up again the question of the biological decomposition of lignin upon which subject many

(10) A. G. Norman—" The Hemicelluloses. I. Alcoholic Sodium Hydroxide as a Pretreatment to Extraction." Biochem. Journ., 1935, Vol. XXIX, pp. 945-952.

(11) A. G. Norman and (in part) J. G. Shrikhande—" The Hemicelluloses, II. The Association of Hemicelluloses with Lignin." Biochem. Journ., 1935, Vol. XXIX, pp. 2259-2266.

conflicting opinions have been expressed. Studies on the availability of lignin involve analyses from time to time on materials that are changing in composition. It is very significant that changes are especially marked in those two groupings which contribute so largely to errors in the lignin determination, for pentoses are rapidly fermented away and proteins synthesised under normal conditions of ærobic decomposition. To some extent these two errors are compensatory and their effect varies widely with the nature of the material and period of decomposition. Previous observations have been re-examined in the light of these facts.(12) The ærobic decomposition of lignin in straw has been studied and determinations made over a period of eighteen months by four different methods, all of which show losses of 40-50 per cent. of the lignin in the first year and 50-60 per cent. in eighteen months.(13) Lignin is certainly not so resistant to biological attack as has sometimes been claimed, but being the most resistant plant constituent tends to accumulate. Highly decomposed organic residues composed largely of lignin and protein are readily susceptible to oxidation, and this property is being investigated in humic residues from various sources.

Certain of the oak timbers of Rothamsted House have been very extensively attacked by the Death-watch Beetle, and on their replacement the opportunity was taken of analysing samples of the decomposed wood and comparing them with the sound wood from the same source. The results leave no doubt that the main constituent removed by the larvæ was the cellulose, and in so far as it was possible to form any estimate, the total loss suffered by the wood was in the region of one third.(14)

Other Investigations. The oxidation of amino acids with hypochlorite has been studied in detail, and the route of the reaction and products determined. Glycine gives rise to CO_2, water and gaseous N, through the intermediate formation of HCN, which is subsequently hydrolysed to formic acid and ammonia, both then being completely oxidised. The rate of the reaction is enormously affected by the *p*H of the mixture, being most rapid in the region of *p*H 7-9.(15) When extended to higher amino acids, this work has provided another example of the great disparity between the first and succeeding members in a homologous series, since the products and conditions of oxidation are very different from those found for glycine. The acids formed from the cyanide are not oxidisable, and from a dibasic amino acid, a cyano-acid has been obtained and identified.

DESIGN OF FIELD EXPERIMENTS

The earlier work of the Statistical Department included the designing of field experiments so that a valid estimate could be made of the magnitude of the errors affecting the results, and at the same time as much as possible of the variation due to soil irregularities

(12) A. G. Norman—"The Biological Decomposition of Lignin." Sci. Progress., 1936, Vol XXX, pp. 442-456.
(13) A. G. Norman—"The Decomposition of Lignin in Plant Materials." Trans. 3rd Internat. Cong. Soil Sci., Oxford, 1935, Vol. III, pp. 105-108.
(14) A. G. Norman—"The Destruction of Oak by the Death-watch Beetle." Biochem. Journ., 1936, Vol. XXX (in press).
(15) M. F. Norman—"The Oxidation of Amino-acids by Hypochlorite, I, Glycine." Biochem.. Journ., 1936, Vol. XXX, pp. 484-496.

could be eliminated. This purpose was accomplished, and designs such as randomised blocks and the Latin square are now superseding the older types of lay-out in almost all classes of agricultural experiment, both in this country and overseas.

During the last few years attention has been devoted to methods of increasing the efficiency attainable by simple randomised blocks and Latin squares, and to methods of widening the scope of a single experiment so that several problems can be investigated concurrently. *Factorial designs* have been developed, in which all combinations of different levels of several treatments (or factors) are included. A simple and very effective example of this type of design is the 27 plot experiments of the factory sugar beet series. In these experiments all 27 combinations of double, single and no dressings of each of the three standard fertiliser components, nitrogen, phosphate and potash are represented, only one plot being devoted to each treatment combination. Each plot is in effect used three times over, once to assess the value of nitrogen, once for phosphate and once for potash. In addition, information, which would be wholly lacking if three separate experiments, each confined to one of the three fertilisers, were used, is obtained on possible variations in response to one fertiliser at different levels of the other two. Such factorial designs, therefore, represent a great advance in experimental technique, and they will probably supplant the simpler methods in the same way as randomised blocks and Latin squares have supplanted the older systematic arrangements.

The attention of the department has also been directed to problems of sampling, which are of immense importance in agricultural experiments. The most efficient technique in any given instance can be determined only by statistical methods; indeed if statistical principles are not borne in mind sampling may be almost unbelievably inefficient. An example of the rapid advances in knowledge that can be obtained by the discriminating use of a good sampling technique, applied co-operatively by workers at several centres, is provided by the sampling observations of the growth of the wheat crop, which are described in a later section.

SOILS

The chemical and physical work consists in attempts to discover the composition and constitution of the soil, and to follow the changes taking place therein.

The clay is recognised as one of the most important components and much work is being done on it in the Chemical Department. Dr. Nagelschmidt has found by X-ray analyses that its commonest constituent differs from all known minerals, but is apparently related to halloysite: he is also studying the swelling of the montmorillonite lattice in presence of water. This investigation requires continuous access to very costly physical apparatus and we are greatly indebted to Sir William Bragg for allowing all that side of the work to be done in the Davy Faraday laboratory of the Royal Institution.

Soil Analysis. Considerable attention has been given to the old problem of finding some chemical means of forecasting the probable effects of fertilisers. For soils suffering from some serious deficiency this is relatively easy, but for soils that have been reasonably well farmed and manured none of the present methods is adequate. An examination of some 15 different methods was recently made by members of the International Society of Soil Science, but none of them proved entirely satisfactory. The rapid methods put forward from time to time are liable to give misleading results. Dr. Crowther, in conjunction with Mr. Warren, Dr. Richardson, Miss Heintze, Dr. Nagelschmidt and other members of his staff is examining the soils of the various plots on which sugar beet and potatoes are grown, to discover how far the results of the field experiments accord with the expectations based on various methods of chemical analysis.

Soil Moisture. In the Physics Department, a notable achievement has been the straightening out of the difficult problems associated with the moisture relationships of the soil. For many years these have caused considerable difficulty : a scale has now been devised which introduces the same kind of order and simplification as the *p*H scale has done for soil acidity. This work is so important to soil workers that a summary of it is given here though the description is necessarily very technical.

When wet soil is placed in an atmosphere of fixed relative humidity (*h* per cent.), evaporation continues until the moisture content has been reduced to a value which depends on the nature and previous moisture history of the soil sample and on *h*. When evaporation ceases, the free energy of the water remaining in the soil is less than that of pure water in bulk by $\frac{RT}{18} \log \left(\frac{100}{p}\right)$ ergs per gram. Dividing by the gravitational acceleration *g*, this free energy difference is given by the height in centimetres of a column of water that expresses, in effect, the " suction " with which the remaining water is retained ; or, looked at another way, the effective height above a free water-table. Evaporation into a 50 per cent. relative humidity atmosphere develops a suction in the remaining water equivalent to 1,000,000 cm. of water, a column higher than Mount Everest. The difficulty of comparing such suctions with those developed as the result of drainage to a water table, which are of the order of 1,000 cm. and less, has been met by using the logarithms of these figures. By analogy with Sørensen's logarithmic acidity scale the symbol *p*F has been used (F being the recognised symbol for free energy).

The suction force exerted by the roots of plants which have just reached the " permanently wilted " condition is usually between 10,000 cm. and 20,000 cm., or between *p*F 4.0 and *p*F 4.3. There are great experimental difficulties in the way of measuring evaporation into atmospheres more humid than about 95 per cent. saturation Hence 60,000 cm., or *p*F 4.78, the suction developed by evaporation into an atmosphere over 10 per cent. sulphuric acid (95.6 per cent. relative humidity) is about the lowest value obtainable in this way. On the other hand, the highest value obtainable by vacuum suction through a filter is 1,000 cm., or *p*F 3. Fortunately, freezing point determinations enable this gap to be bridged. One degree centigrade freezing point depression corresponds to a suction of 12,700 cm. or *p*F 4.1.

Mr. Botelho da Costa, under the direction of Dr. Schofield, has used the improved freezing point technique mentioned in the last report to measure the *p*F of the water that remained in seven soils, of widely different character, when beans growing in them became "permanently wilted." The values so determined fell between *p*F 4.0 and *p*F 4.4, although the corresponding moisture contents ranged from 2.9 to 21.6 per cent. of dry soil. Taking the mean value of *p*F 4.2 and reading the corresponding moisture content from the curves plotted from the freezing point measurements, the values obtained differ on an average by only 0.7 per cent. from the moisture contents found in the wilting experiments. The greatest difference was only 1.2 per cent., which would be of small consequence in field measurements.

The moisture content of a soil at permanent wilting does not bear a constant ratio to the "moisture equivalent" determined in the Brigg-McLean centrifuge as these authors claimed. The freezing point determinations show why this is so. For a medium textured soil the "moisture equivalent" corresponds to about *p*F 2.9. This was confirmed by the freezing point measurements which showed that the curves connecting *p*F and moisture content differ in *shape* from soil to soil, and for the seven soils examined the ratio of the moisture content at *p*F 2.9 to that at *p*F 4.2, instead of being constant at 1.84, varied from 1.5 to 5.3.

By using the *p*F scale the results of measurements by direct suction, centrifuge, freezing point and evaporation into atmospheres of controlled humidity can be plotted on the same graph and curves connecting *p*F and moisture content can be traced from saturation (*p*F 0=1 centimetre suction) to oven dry (approximately *p*F 7). This work has brought into prominence the great importance of distinguishing between wetting and drying conditions. The suction needed to withdraw water from a moist soil is, in general, greater than that against which water will enter the soil at the same moisture contents. This fact, coupled with the slowness of wetting of clay by water at *p*F 3 or above, has been shown to account in a general way for the characteristic moisture distributions met with in the field.

SOIL MICRO-ORGANISMS

The growth of the plant, in nature is determined not only by chemical and physical soil factors but also by the soil micro-organisms, which are studied in the Micro-biological, Bacteriological and Fermentation Departments. The more these organisms are investigated, the more numerous they appear. Twenty-five years ago, the bacterial population in one gram of soil (about a salt-spoonful) would have been assessed at about 5 to 10 millions. It is now known that the figures are very much higher. A gram of field soil may contain several thousand million bacteria, many thousands of protozoa, millions of actinomycetes and fungi, in addition to an unknown number of eel-worms, besides other organisms not invariably found, either because they are not always present or because the technique is defective. The greater accuracy of modern bacterial counts is due to the method of counting bacterial cells in soil under the microscope which has been developed in the Bacteriology Department and now gives reliable quantitative results.

Three main groups of investigations are carried out :—

1. The decomposition of organic matter and its conversion into simpler substances. This is at the basis of the production of plant food in nature, but it has also many applications on the farm and in the countryside ; three of which are studied in detail :

(*a*) The decomposition of plant residues in the soil in relation to green manuring, ploughing-in of leys, residual values of farmyard manure.

(*b*) The conversion of straw and other plant residues into organic manure. This process has been taken up by Adco, Ltd., and developed by them into a workable process for making artificial farmyard manure. While English farmers do not make much use of it the method is used a great deal by gardeners and to a still greater extent by planters and growers overseas. Some 50,000 tons or more of manure are probably made annually through this one organisation and there is reason to believe that the total made in all countries by the process is not less than 200,000 tons annually.

(*c*) The biological purification of effluents from sugar beet and milk factories.

The last-named investigation is carried out in the Microbiological and Fermentation Departments under the ægis of the Department of Scientific and Industrial Research ; the work is done partly at Rothamsted and partly in the factory.

In the Bacteriological Department the interesting work on clover organisms continues, and it is shown that in the soils of certain hill districts there occur harmful strains which do not themselves benefit the clover plant, and which prevent most beneficial strains from forming nodules. A few beneficial strains, however, are able to overcome the harmful effects of the bad strains and enable the plant to make full normal growth. Experiments have been begun on the inoculation of these beneficial strains into soils containing the harmful ones, and the results are distinctly promising. The first essential is a survey of the hill districts to see how far these harmful strains are prevalent, and to what extent the highly efficient strains already isolated are able to act generally in overcoming their bad effects.

The process of infection has been studied in considerable detail. It is impeded by the presence of nitrates which not only reduce infection but also reduce the activity of nodules already formed. Part of the effect consists in checking the deformation of the root hairs which is an essential preliminary to infection : this, however, can be counteracted by adding dextrose. Such nodules as are formed in presence of nitrate are abnormal in several ways. The distal cap of the cells, normally thin-walled and actively dividing, develops much thickened cell walls and the cell-division soon ceases. The lateral endodermis and the cells surrounding the vascular strands become heavily suberised. These changes result in the central nodule tissue becoming enclosed in a layer of thick walled cells. This central tissue shows evident signs of starvation.

PLANT PATHOLOGY

Virus Disease. The group of workers who have since 1929 studied virus diseases under Dr. J. Henderson Smith, suffered its first loss in October, 1935, when Dr. John Caldwell left to take up the Lectureship of Botany in University College, Exeter. His last important contribution was to show that inoculation with a strain of virus conferred in certain conditions some degree of immunity against a virulent strain of the same or a closely allied virus. Dr. Sheffield, in studying by micromanipulative technique the localisation of virus in the plant and within the single cell, has found that individual cells differ in susceptibility to virus attack, only 6-12 per cent. of injected cells responding to inoculation.

Mrs. Watson has carried out a series of quantitative investigations on the relations between the insect vector and the infection it produces. The amount of infection increases as the time of feeding the infected insect on the healthy plant is raised from 2 minutes to 12 hours, but only by about 20 per cent. As the time of feeding on the infected plant, before transference to the healthy plant, is increased from 2 or 5 minutes to 1 hour, the amount of infection falls by 50 per cent., but rises again after 1 hour's feeding. The fall may be due to development of an antibody in the insect body and this is being investigated with the help of Miss B. Mitchell. An infected insect, transferred from one healthy plant to a second, may infect the second plant as well as the first, but not if the period on the first plant exceeds one hour. This is of importance in the question whether insect transference with viruses of the type under experiment is purely mechanical or requires ingestion by the feeding insect.

Mycology. A new glasshouse for mycological work was completed in October. It includes one large compartment, 24 ft. by 30 ft., for general mycological work, and four small compartments, 11 ft. by 11 ft., which can be made insect-proof when required. Heating is by a thermostatically controlled, oil-fired boiler. The new house has already proved that it is excellently adapted for the work required.

The completion of this house enabled investigations to be commenced towards the end of the year on the club-root disease of crucifers. It is proposed to examine first the well-known action of lime in controlling the disease, and to determine if possible whether this is due to an effect on the disease-producing organism itself, or whether it is due to an increased resistance conferred upon the host plant. An effort will also be made to find an explanation for those cases in which lime is stated to have no beneficial effect.

The work on root-rot diseases of cereals has been continued. F. J. Greaney, on leave from Canada, co-operated with G. Samuel in an investigation on the gradual invasion of wheat root systems by fungi as the crop ripens. They found that the fungus *Fusarium Culmorum*, which is usually regarded as a disease-producing organism was much more widely distributed than was imagined, and that healthy wheat crops by the time they were reaped often had a considerable amount of the fungus present on the roots without suffering any apparent harm. Studies will be made later of the conditions under which this fungus becomes a parasite of importance.

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ENTOMOLOGY

The Entomological Department is concentrating on a study of the factors that determine the changes in number and the movements of insect populations. Observations show that all the ordinary harmful insects occur on our farm but in general their numbers are so small that they do little damage. Occasionally, however, one or more species multiplies with extraordinary rapidity and devastates the crop. The spring of 1935, for example, was not favourable for insects in general, yet one species, the Pygmy Mangold Beetle, multiplied so inordinately that it completely ruined the mangolds on Barnfield, on which mangolds have been grown every year since 1876 (with two exceptions) and where the insect has certainly been living for a long time. In certain investigations, the general procedure is to take systematically frequent " samples " of the insect population of the farm. Methods have been devised for making sample censuses that can be subjected to statistical examination and these are continuously improved to facilitate their use in practice. Approximately four times as many insects were caught from March to October in 1935 as in the corresponding period of the previous years, the difference being mainly in the Lepidoptera and the Diptera. Full meteorological observations are taken, and relations are sought between these and the census figures. The numbers of nocturnal insects caught in a light trap show a definite lunar periodicity, with low numbers at full moon and high numbers at new moon. The effect is more marked for some groups of insects than for others and is most significant in the *Noctuidae*.

A higher proportion of females was obtained in the *Noctuidae* in a trap at a height of 35 feet above the ground, than in one about 3-4 feet above the ground.

A mechanical trap for insects, designed and tested during the year has been found valuable for estimating the activity of small slow-flying insects, such as green fly. It has already been adopted for use in studying the transmission of potato virus disease by insects.

Dr. Barnes has completed the first series of his studies on variation in population of certain insects, which include nine years' observations in the case of the wheat midges. The figures for 1935 for the latter insect show an increase over the previous two years and so fit very closely to the periodic curve which was suggested three years ago.

The analysis of records of insect migration has thrown light on two important problems. Considerable evidence has been found that some British migrant butterflies and moths make a return flight to the south in the autumn, also that one of the migrant Hawk moths which occurs in both Europe and America, at times as a pest, shows a tendency to occur simultaneously in both Continents. This indicates that the causes of migration in this species must be sought for in factors that are either very widely spread or are positively correlated in the two Continents.

INSECTICIDES.

Dr. Tattersfield and Dr. Martin investigate the direct attack on harmful insects by means of insecticides. Certain vegetable products are found to be extremely effective and have the further advantage that they are harmless to farm animals and to man. Among them the most important are products from the tropical plants, Cubé, Derris, Haiari and others, and the non-tropical Pyrethrum. Methods of chemically evaluating these are investigated, and experiments are made to test the effect of manures on pyrethrum. Dr. Tattersfield's work has created so much interest in the United States that one of the large manufacturing firms there invited him over in May, 1935, to discuss problems with their experts and those of the United States Department of Agriculture.

During 1935 work has been concentrated on the differentiation of the species and varieties of derris root. Henderson's valuable studies in Malaya of the botanical characters of members of this genus give no indication of their potential value as insecticides nor whether the constitution of the resins is determined by genetical or environmental factors. We have had specimens of *Derris elliptica* possessing little or no toxicity to insects, and samples of *Tephrosia vogellii* and of *Mundulea suberosa* vary widely in activity, despite the fact that they appear to be true to type. From these plants a number of crystalline derivatives have been isolated by various investigators. Only one, " rotenone," is highly toxic to insects, the others appear to be either altered in the process of extraction or derived from precursors of greater insecticidal power. Three samples of derris, *D. elliptica, D. malaccensis,* and the " Sumatra-type," all contained about the same amount of extractives, but the resins differed markedly in properties. The rotenone content was highest in *D. elliptica* and lowest in the "Sumatra-type." *D. malaccensis* and the "Sumatra-type" resins yielded an optically active resin from which was isolated optically inactive " toxicarol," a compound closely related to rotenone, but with relatively little insecticidal power. The resins derived from these three types of root when dissolved in benzene were optically active and laevorotatory, and although their rotations were in the same order as their insecticidal powers the relationship was not quantitative. When a solution of caustic potash in methyl alcohol was added to the benzene solutions of the resins, those derived from *D. malaccensis* and the " Sumatra-type " changed instantaneously in sign and became dextrorotatory, while those from *D. elliptica* became less laevorotatory but did not change sign. The resin extracted by caustic potash from the " Sumatra-type " resin gave the change-over from laevo- to dextrorotation, but the residue reacted like the resin from *D. elliptica*. The induced dextrorotation declined with time at a rate depending on the amount of methyl alcohol added with the potash.

Direct insecticidal tests showed that no single method, including the estimation of the dehydro-compounds derived from the resins by suitable oxidation and dehydration processes, truly assessed the relative potencies of these three roots, and our chemical work shows that the toxicity of the resins is determined not only by rotenone, but by the precursors of deguelin and toxicarol also.

In the field experiments on pyrethrum at Woburn manuring had no significant effect on yield.

Soil Insecticides. The possibility of finding a chemical substance effective for soil sterilisation and as a soil insecticide has recently been revived. Some years ago it was shown at Rothamsted that certain benzene derivatives were very promising, but they were then unobtainable on the large scale. They are now, however, available in quantity and at relatively low cost. The subject has therefore been re-opened and Major Ladell appointed to discover how best to find out the effects of these substances against wireworm and eel-worm in actual field conditions ; these two pests being chosen because they are already doing much damage, and the eel-worm is threatening to do more.

This work has been greatly facilitated by Major Ladell's new method for the rapid separation of insects and other arthropods from soil. The sample is stirred in a heavy non-toxic solution (magnesium sulphate, sp, gr. 1.1) through which a stream of fine air is bubbled to assist in floating the insects to the surface. The froth containing the insects is drawn off over a sedimentation tank and the insects finally separated by filtration.

Over 95 per cent. of the soil fauna can thus be separated from a sample of about 5 lb. of soil in about 20 minutes. Two field experiments on the use of insecticides against soil insects were carried out in 1935, one against wireworm and the other against root eelworm, four insecticides in single and double doses being used. Significant differences were observed between the numbers of eelworm cysts in the control and some of the treated plots. There was also a noticeable decrease in the number of wireworms on some of the plots. Both experiments are being continued.

BEE-KEEPING RESEARCH SECTION : 1922-1935.

Organisation and Equipment. Shortly after the war the Development Commissioners made a grant to the University of Cambridge for investigations on problems of bee-keeping to supplement the work on Bee Diseases they were financing at the University of Aberdeen.

In 1921 the investigations were by mutual agreement transferred to Rothamsted along with the equipment and the stocks of bees. In 1922 Mr. D. M. T. Morland came from the Ministry of Agriculture to take charge. He has been assisted throughout by Arthur Rolt, while B. A. Young was a voluntary worker for about one year and others for shorter periods. In 1934 the beekeepers asked that the work should be extended to deal with bee diseases, and the British Bee-Keepers' Association generously undertook to collect one half of the money required, if the Ministry of Agriculture would provide the rest. This was done, and Dr. H. L. A. Tarr was appointed as Bacteriologist to investigate brood diseases.

The section forms part of the Department of Entomology.

At the inception of the work at Rothamsted an Advisory Committee was appointed consisting of Messrs. Bocock, J. C. F. Fryer, Cragg and W. Herrod-Hempsall, with Sir John Russell as Chairman and Dr. Imms (Head of the Department of Entomology) as Secretary. Meetings have been held once or twice a year to discuss the progress made and to advise on future investigations.

The present Committee consists of Mr. J. C. F. Fryer, Mr. W. Herrod-Hempsall (Ministry of Agriculture), Miss A. Betts (Apis Club), Dr. Gregg, Mr. J. Herrod-Hempsall, Rev. W. H. Richardson (British Bee Keepers Association), Dr. H. Schütze, Dr. J. C. G. Ledingham (Lister Institute), Brother Adam, Dr. F. Thompson, Mr. B. C. Berkeley, Mr. Gilbert Barratt. Two of the members representing the B.B.K.A. were appointed by that body when they took over the responsibility for the collection of the Beekeepers' share in the fund for Foul Brood disease research : the two members representing the Lister Institute were appointed at the same time to advise on the bacteriological side of the work.

The experimental apiary (4)[1] is situated on the Rothamsted Farm in a sheltered position protected by trees and hedges. It usually contains thirty to forty colonies mostly on British Standard Frames, about half being in W.B.C. hives and the rest in " National" single walled hives. These are arranged regularly, but in such a way as to avoid excessive drifting of the bees. The field laboratory contains store room, extracting room, and workshop and has water and electricity laid on.

Two or three out-apiaries are usually maintained for special investigations and for work on brood diseases.

The main sources of nectar are white clover, the lime trees of the adjacent avenue and, in spring, wild cherry and holly. Willows of both pollen- and nectar-bearing varieties have been planted at the apiary and a small orchard stands opposite. The spraying experiments carried out on these trees are watched with some anxiety, but up to the present there has been no evidence of poisoning of the bees.

For the more technical investigations there is a large laboratory in the Entomological Department.

Hive Temperatures. Observations on hive temperatures by means of thermocouples were commenced by Mr. Bullamore while the apiary was still at Cambridge ; they were continued at Rothamsted with improved instruments embedded in the foundation wax. Interference with the brood was thus avoided but the temperatures recorded were of course those of the brood and not of the air in the hive.

Daily readings, winter and summer, were carried out for a number of years in hives with different comb arrangements. Once a month readings were taken every three hours for a period of 24 hours or more. The statistical analysis of the data was made under the supervision of Mr. Irwin, but was never published. The results tended to confirm those obtained by Phillips and Demuth in North America and were summarised at the 5th International Entomological Congress in Paris in 1933 ([15]).

Feeding Experiments. Two feeding investigations were undertaken in 1929([10]), these were :—

(*a*) *Comparison of Cane and Beet Sugar.* Some beekeepers had

(1) The numbers in brackets refer to the Bibliography on pp. 64—66.

been accustomed to attribute their winter losses to the use of beet sugar as food. Two series of hives were deprived of most of their natural stores, one was given cane sugar first as syrup then as candy, and the other beet sugar in similar form. No difference in wintering attributable to the sugar could be detected. This experiment was repeated over a series of winters.

(*b*) *Ripening of Syrup*. A mild organic acid such as tartaric acid or vinegar is sometimes used in preparing syrup for autumn so as to invert the cane sugar and prevent granulation in the comb. Experiments showed that boiling syrup with acetic acid for 30 minutes inverted only 15 per cent. of the sugar, while merely bringing the syrup to the boil was almost ineffective. Syrup to which acid has been added was not so readily inverted by the salivary juices of the bees as was the plain sugar, so that samples of the sealed stores taken from the hive after feeding showed an advantage in favour of the untreated sugar. The inhibiting action of the acetic acid on the invertase of the bees' saliva had defeated the object of adding it.

Weighing Hives. Even in a commercial apiary it is most desirable to have a hive on scales, and in an experimental apiary this is a necessity. Three sensitive self-recording balances are used to record continuously the changes of weight of the stocks kept on them(8). One of these has been in continuous use for nine years and the records show a marked similarity in the dates of the onset, peak and cessation of honeyflow in different seasons.

The relation between the daily fluctuations, which give a measure of the bees' activity, and the weather records (sunshine, temperature, rain, wind, in decreasing order of importance) have been studied by P. V. Sukhatme.

Study of Swarming. Swarms are undesirable as they not only cause trouble and loss of time, but also they divide the working force of the bees at the season when it is most important to keep it intact. The brood food theory of Gerstung seems to offer a reasonable explanation of swarming and it has received some confirmation from Rösch's work on the division of labour in the hive(12).

Experiments with bees marked on emerging from the cell and then introduced into observation and other hives, tend to corroborate Rösch's work. As they become older bees are promoted from the various grades of nursing duty to household work, such as wax building and the ripening and storing of honey, and finally to field work.

According to the brood food theory it is a surplus of nurse bees over the requirements of the brood that causes the building of queen cells. A surplus occurs in every normal stock immediately after the peak of brood rearing is reached ; its magnitude varies according to a number of factors and it is largely this which determines whether swarming occurs or not.

The introduction of marked bees into a colony induced swarming : indeed in one year the only swarms in the experimental apiary came from such colonies. The withdrawal of brood from other strong colonies to provide bees for marking and transfer to the experimental hives had lowered the proportion of nurse bees to brood in the one lot and considerably augmented it in the other. Removal of much of the sealed brood from the nest and keeping the resulting bees away until they are past nursing age forms the basis of several systems of swarm control.

A Conference on swarming was held at Rothamsted in 1935 and was largely attended by beekeepers. A report on this Conference was published(38).

Bee Diseases

Acarine or "Isle of Wight" Disease. In 1927 Mr. Allen experimented on the treatment of Acarine disease by vapours introduced into the hive. Oil of wintergreen and sulphur dioxide were the only ones that killed the mite without at the same time killing the bee. The Frow treatment had not at that time been devised and nitrobenzene was not tried ; when Mr. Allen left the work was discontinued ; it will, however, be resumed during the coming season.

Brood Diseases. Dr. Tarr finds that American foul brood is a definite disease due to *Baccilus larvae,* but the so-called European foul brood is more complex and appears to be associated with at least two organisms. A third disease generally called "addled brood" may be due to some trouble in the queen and is not due to a pathogenic organism.

American foul brood and addled brood are more common than European foul brood.

American foul brood appears to attack quite strong bees, but there is distinct evidence that European foul brood is more prevalent in weak stocks and in neglected apiaries.

A Conference to discuss problems of brood disease was held at Rothamsted in May, 1934(37).

Senses and Sense Organs of Bees. H. C. F. Newton investigated the so-called olfactory organs or "campaniform sensillæ" scattered over the bodies of bees, dealing particularly with the structure and development of the sensillæ occurring in the wing bases of adult worker bees. He finds no evidence that the actual termination of the nerve fibre is exposed to the outside air.(23)

J. Marshall(2) has made a preliminary study of other sensory organs, the contact chemoreceptors on the antenna and fore-tarsus of the honey bee. He found that the bee responds when a solution of saccharose of an average strength of M/12 comes into contact with the antenna, whereas a strength of M/1 is required to elicit a response from the fore-tarsus. Amputation of the antenna did not affect the gustatory reactions of the bee but resulted in a complete loss of olfactory recognition of wax comb. It was concluded that the antenna are the seat of all the olfactory organs which perceive mild odours.

Honey Problems

" Frosting " of Granulated Honey. Preliminary observations suggest that this phenomenon, due to the formation of an irregular air space between the dextrose crystals and the jar, is aggravated by the large quantities of air that the modern centrifugal extractor incorporates into the honey and which is not removed in subsequent operations. It can be got rid of by incubating for two days at 40°C, but this involves loss of both colour and aroma of the honey. Placing the honey in a vacuum was not effective as on re-admitting air the bubbles were re-absorbed.

Heather Honey. Thixotropy. Heather honey is popularly supposed to be able to hold more moisture than other honeys without fermentation, and it was therefore desirable to draw up for the National Mark Scheme a special schedule for heather honeys, allowing a reasonable excess of moisture. The special water-holding powers are associated with the capacity to form a gelatinous structure on standing which is reversibly destroyed by stirring, a property well-known in other materials under the name of " thixotropy " (page 47).

G. W. Scott Blair has investigated this problem and has described a simple semi-quantitative test for thixotropy by which honeys can be classified [24].

Very few of the many plants from which honey can be obtained yield this thixotropic honey. *Calluna vulgaris* and *Leptospermum scoparium*, the latter from New Zealand, are the only authenticated cases to date (Apr., 1936), except that heated honey from Buckwheat (*Polygonum fagopyrum*) is also reported by Pryce-Jones as thixotropic.

Honeys produced from *Erica* spp. however, are not thixotropic, and should not contain any excess of moisture.

Library

A library of bee-keeping books is being built up and now includes long series of some of the more important bee journals and a number of books and pamphlets on beekeeping. Additions to the collection will be welcomed.

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CROP ESTIMATION AND FORECASTING

SAMPLING OBSERVATIONS ON THE GROWTH OF WHEAT

In 1924 the Agricultural Meteorological Committee was formed by the Ministry of Agriculture and Fisheries, the Department of Agriculture for Scotland, the Meteorological Office and the Forestry Commission, to investigate the effects of the weather on agricultural and horticultural crops. The programme includes sampling observations on the growth of wheat on a plan developed by the Statistical and Plant Physiological Departments at Rothamsted. Ten stations collaborate; at nine of them full meteorological observations are taken. The work is supervised by the Statistical Department, and 1935 was the third year of the full scheme.

The observations consist of counts of plant number and shoot number per unit area, and measurements of shoot height and ear height. At each station two standard varieties are observed at intervals varying from three weeks to a day, according to the state of the crop.

In surveying the results of the first three years Miss M. M. Barnard found a close connection between the height of the shoots at ear emergence and the final yield of grain. Plant number at tillering was negatively correlated with the yield of grain. No other measurement was closely associated with yield. The results are too few to show the effects of variation in meteorological conditions on yield, but at certain stages the effect of the temperature on growth was clearly marked. The wheat crop, in fact, appears to be growing at or near the optimum meteorological conditions, so that the influences of variation of weather are likely to be small and complex, differing with different soil types.

Observed and Predicted Yields (cwt. per acre)

Station	1932-33		1933-34		1934-35		Mean	
	Observed	Predicted	Observed	Predicted	Observed	Predicted	Observed	Predicted
Seale Hayne ..	19.0	25.5	32.4	30.0	26.2	26.2	25.9	27.3
Rothamsted ..	22.2	26.2	32.2	32.4	34.7	32.5	29.7	30.4
Newport ..	35.3	38.8	43.7	43.3	40.0	37.6	39.7	39.9
Boghall	32.8	35.3	35.7	37.8	29.6	26.4	32.7	33.2
Sprowston ..	25.3	30.6	28.3	29.5	20.6	23.3	24.7	27.8
Plumpton ..	—	—	35.2	28.2	47.2	39.4	39.4[3]	33.6[3]
Wye	10.8[4]	—	47.8	41.5	15.2[5]	24.2	—	—
Long Sutton ..	27.6	29.3	—	—	10.8	—	—	—
Mean[1]	28.4[2]	31.6[2]	34.6	33.5	33.0	30.9	—	—

(1) Excluding Wye and Long Sutton.
(2) Adjusted to be comparable (over the same group of places) with the means of the other years, which include Plumpton.
(3) Adjusted to be comparable (over the same set of years) with the means of the other stations.
(4) Serious damage by birds.
(5) Damaged by Take-all (*Ophiobolus graminis* Sacc).

The association between shoot-height at ear emergence, plant number at tillering and yield of grain, enables a formula for the prediction of yield to be calculated. Working with the mean of the two standard varieties, and the first six stations of the accompanying table, it was found that for every increase of an inch in height (measured to the top of the sheath of the youngest leaf) an increase in yield of 1.32 cwt. per acre is to be expected, and that for every increase in plant number of 1 per foot-length of row, there is a decrease in yield of 0.62 cwt. With a height of 30 inches and a plant number of 10 per foot, the expected yield is 34.3 cwt. The values of the yields calculated from the formula are shown in the table for comparison with the actual yields.

These results are not sufficiently extensive to determine the accuracy of forecasts based on height measurements, but they suggest that simple measurements of this type may enable good forecasts to be made for any particular field.

Such forecasts, however, would be of little use in predicting the average yield of a district unless one knows how closely the yield on the observation plot is related to that of other fields in the same district.

The degree of association between fields in a district was estimated from samples taken by the crop weather observers in 1934 and 1935 from fields on different farms : the variability from field to field was remarkably high. In consequence both estimates and forecasts of the average yield of a district need to be based on observations of commercial crops.

The observations on wheat will be extended to study the possibilities of crop estimation at and prior to harvest. Suitable methods for sampling sugar beet and potatoes are being sought ; the Harper Adams College is co-operating in the sugar beet work.

DEPOSITS FROM THE ATMOSPHERE

Since 1915 Rothamsted has co-operated in the investigation of Atmospheric Pollution organized by the Department of Scientific and Industrial Research. Certain analyses of the rain and of the dust deposits are regularly made, and some of the results have now been summarised. (1) For the second year in succession our deposition gauge collected the smallest total solids out of the 98 gauges in use throughout the country. The total for the period April 1st, 1934, to March 31st, 1935, was made up as follows :

		Kg. per hectare	Cwt. per acre
Insoluble Matter	Loss on Ignition	59.4	0.473
	Ash	88.1	0.702
Soluble Matter	Loss on Ignition	93.9	0.748
	Ash	91.1	0.725
Total		332.5	2.648

The total deposit for the present year is the lowest since 1925-26 when a total of 307.5 kg per hectare (2.45 cwt. per acre) was collected. The average total for the last ten years is 401.1 kg per hectare (3.20 cwt. per acre) and the highest, recorded in 1929-30, was 507.4 kg. per hectare (4.04 cwt. per acre). The well-known positive correlation between rainfall and deposition of soluble matter is clearly apparent, and in consequence of this no secular change either for better or worse is detectable with certainty over this period.

The average monthly deposit was greater during the summer than the winter. This is a regular feature of our records, but it is particularly interesting this year, because rainfall had the opposite distribution.

	April to Sept.	Oct. to March
Average Monthly Rainfall, mm.	43	51
Average Monthly Deposition, Kg/hectare	31.8	23.6

(1) B. H. Wilsdon.—" Results of a statistical examination of records of deposit gauges." Appendix to Dept. Sci. Ind. Res., Twenty-first Report on Observations in the Year ended 31st March, 1935.

The recent analysis undertaken by B. H. Wilsdon shows that in London the rate of deposition of soluble matter is less in summer than in winter. This may be partly due to a lower rate of production : but taken in conjunction with the Rothamsted results, may indicate that summer conditions favour the transport of this fraction into the surrounding country. The seasonal distribution indicates that little of what we collect originates in the domestic fires of the neighbourhood, which are much more active in winter.

The fact that only 27 per cent. of the deposit at Rothamsted is non-combustible and insoluble in water shows that very little can be ascribed to dust from neighbouring fields and roads. Most of it comes from other sources.

At some of the other centres much higher values were obtained ; near the Liverpool Docks, for instance, the atmospheric deposit amounts to almost one ton per acre per annum as against our 2½ cwt. Here also, as at Rothamsted, about half the soluble material and about one-third of the insoluble material is combustible: the difference in the amounts of these deposits appears to be much greater than the difference in their composition.

FARM HUSBANDRY INVESTIGATIONS

The investigations outlined above necessitate a considerable amount of field work which is carried out on the farm but this does not occupy anything like the whole of the land available. The classical fields are of course given up to their own crops, but all the newer experiments are made on the non-classical fields. Only certain areas, however, are suitable and the land available in any year is further restricted by the wholesome rule, to which we adhere closely, that an area of land once used for an experiment should not come again into experiment until after the lapse of three years. There is thus a considerable area of land to be farmed on ordinary commercial lines, besides numbers of live-stock needed for the consumption of the farm produce or for the testing of the value of the various fodder crops. Numerous opportunities arise for carrying out farm husbandry investigations by the farm manager and the farm recorder acting in conjunction with other members of the staff. These investigations are not connected with the main programme, but they are in all cases of considerable agricultural importance. Those at present in hand are set out below.

1. A comparison of electrical power with the tractor or stationary oil engine for the performance of work about the farm buildings.

This is being done under the aegis of the Royal Agricultural Society and it consists in finding the equivalence between units of electricity and gallons of paraffin for the various operations, account being taken of such details as starting and stopping. The results are expressed in terms of power consumed per ton of material threshed, ground, etc. In all cases the work is to be done in the ordinary farm way using ordinary farm labour ; the results are to show what happens on good but ordinary farm conditions. They were discussed at a Conference held at Rothamsted in February, 1936, the report of which is now issued (p. 13).

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2. The Production of Lamb. A breeding flock of 200 " Half-bred " ewes is maintained for ordinary farm use, and on this experiments are made :

(a) to test the effects of flushing ;
(b) to compare four-teated ewes with two-teated ewes as mothers ;
(c) to discover whether it is really necessary to import continuously new stock from the North or whether the breeding ewes can be produced here ;
(d) to study the advantages and disadvantages of breeding from ewes in their first year.

3. The Production of bacon. Some 20 breeding sows are kept and the progeny sold mostly for bacon.

Among the problems studied have been :

(a) the relative values of wet and dry feeding ; of restricted and unlimited feeding ;
(b) the value of green food ;
(c) the effect of the state of division of the food ;
(d) the effect of exercising the animals on the quality of bacon they yield.

THE DISSEMINATION OF THE RESULTS

This is one of the most difficult problems in connection with research work and it has no simple solution.

Several methods are adopted at Rothamsted :

1. The scientific papers are published in the appropriate journals and periodically collected as Volumes of Memoirs. At suitable times a monograph is published in which the various scattered papers dealing with a particular subject are combined and the necessary connecting and rounding-off experiments are made so as to give a coherent account of its present position. Seven of these have already been published dealing with Soil Fertility (the Director) ; Physical Properties of the Soil (Dr. Keen) ; Soil Micro-organisms (a joint production) ; Experiments on Grassland (Dr. Brenchley) ; British Aphides (Dr. Davidson) ; Soil Microbiology (Mr. Cutler and Miss Crump) ; the Woburn Field Experiments (the Director, Dr. J. A. Voelcker, with a Statistical Report by W. G. Cochran). The Director's Monograph on Soil Conditions and Plant Growth has passed through six editions and a seventh is in preparation ; it has been translated into French, German, Spanish, Russian and Ukrainian and pirated in China by photographic reproduction, omitting the name of the publisher but inadvertently including that of the printer. Other of the Director's books have been translated into Portuguese, Italian and Armenian and negotiations have been made for translation into Japanese, Hungarian and other languages. Dr. Keen's monograph on the Physical Properties of the Soil has been translated into Russian and Dr. Brenchley's monograph on grassland into German.

2. The practical and technical information is disseminated in three ways :

(a) by Conferences at Rothamsted at which practical men are invited to give their experiences and the Rothamsted staff and other experts also read papers. The proceedings are then published cheaply as booklets.

(*b*) by lectures to farmers' organisations This falls largely on Mr Garner, but the senior members of the staff including the Director regularly give a certain number. Field demonstrations are arranged at outside centres wherever the experimental results are suitable: this is usually done by Mr. Garner or Dr. Crowther, in association wherever practicable, with the County Organiser. Articles for the technical press are frequently written.

(*c*) by demonstrations at the Rothamsted Farm, usually by Mr. Garner, Captain Gregory and Mr. Moffatt. The numerous visitors to the laboratories are dealt with by Messrs. Garner and Gregory and a group of rota guides, which includes selected voluntary workers and all members of the scientific staff other than Heads of Departments. The number of visitors increases every year.

In addition there is a fair amount of visiting of farms when the owner not infrequently brings together a little group of neighbours for discussion.

THIRTY YEARS' WORK IN THE BOTANICAL DEPARTMENT. 1906-1936.

WINIFRED E. BRENCHLEY, D.SC.

During the early years of Rothamsted the laboratory work was entirely concerned with matters arising from the field plots, chiefly chemical in nature, and this was carried on by a chemist and a few laboratory assistants under Sir Henry Gilbert. No regular botanist was needed, but when occasion arose a trained man was engaged temporarily to supervise the botanical separation of Park-grass Hay, this work being carried on later by Mr. J. J. Willis. By 1906 the scientific work of the institution was widened, and sub-division into departments gradually became necessary. The James Mason laboratory, erected in that year, served to house the various young biological departments until the general extension of the laboratories began about 1912. During that period the foundations of a botanical department were laid down, and the work was ready for fuller development when increased accommodation and working facilities became available.

In the early days of this century the question of the "strength" of wheat was receiving much attention, and the first problem dealt with in the new department was the possibility of associating the varying strength of wheat with cytological differences in the developing grain, but no such differences could be detected (1). Analyses made at three day intervals from flowering to maturity showed that at each stage the endosperm is filled by uniform material, possessing always the same ratio of nitrogenous to non-nitrogenous material and ash, this ratio being determined by such factors as variety, soil and season (2). With barley, as with wheat,

(1) W. E. Brenchley—"On the Strength and Development of the Grain of Wheat (Triticum vulgare). Ann. Bot., 1909. Vol. XXIII, pp. 117-39.

(2) W. E. Brenchley and A. D. Hall—"The Development of the Grain of Wheat." J. Agric. Sci., 1909. Vol. III, pp. 195-217.

the weight of the whole plant increases steadily until desiccation sets in, after which it falls ; the fall is greater for barley, which is cut dead ripe, than for wheat, which is cut when maturation changes are only beginning. With wheat from Broadbalk the manuring had very little effect on the composition of the grain or straw, whereas with barley from Hoos Field the effect of phosphoric acid starvation was reflected in the results obtained. [3]. Later work on the phosphate requirements of barley emphasized the great importance of adequate supplies in the early stages of growth. Normal development and maximum dry weight are attained if phosphate is supplied for the first few weeks even if it be entirely withheld afterwards, though the actual amount of phosphate absorbed continues to increase steadily if the supply is maintained. On the other hand the absence of phosphate during early growth seriously hinders development, even though an adequate amount is given after short periods of deprivation. [4]. Parallel experiments, as yet unpublished, indicate a somewhat similar response with regard to potash, maximum dry weight being attainable after a few weeks' initial supply, but with nitrogen, increase of dry weight continues with nitrogen supply up to a relatively short time before maturity.

The first work on plant physiology at Rothamsted was concerned with the action of various substances, especially plant poisons, on growth. It had been supposed that all substances deleterious to plant growth act as stimulating agents if they are available only in exceedingly minute quantities, and in 1907 investigations were begun in water cultures to test this hypothesis. Salts of manganese, copper, zinc, arsenic and boron were studied, but, while toxic effects were always produced by relatively small amounts, minute traces did not always have a stimulating action under the conditions of experiment. Arsenious acid and arsenites were far more toxic than corresponding doses of arsenic acid and arsenates. [5].

Boron is less toxic than the other elements tested, but it was not till 1921 that a chance observation drew attention to a far more important question—the possibility that boron might be an essential element for plant growth. Attempts to grow beans in water cultures had always failed, and it so happened that they had never been tested in solutions containing boron till 1921, when a series of *Vicia faba* plants were grown for entomological purposes with various elements in addition to the usual nutrient salts. This was followed up by Miss K. Warington, and it was conclusively established that a trace of boron is absolutely essential for the growth of many plants, and that in its absence the meristematic tissues are adversely affected and death ultimately occurs. In *Vicia* the cambium cells are greatly enlarged in the absence of boron, and breaking down of the vascular tissues proceeds from the stem apex downwards.

(3) W. E. Brenchley—" The Development of the Grain of Barley." Ann. Bot. 1912. Vol. XXVI., pp. 903-28 ; W. E. Brenchley—" The Development of the Flower and Grain of Barley." J. Inst. Brew. 1920. Vol. XXVI, pp. 615-32.

(4) W. E. Brenchley—" The Phosphate Requirement of Barley at Different Periods of Growth." Ann. Bot. 1929. Vol. XLIII, pp. 89-110.

(5) W. E. Brenchley—" The Influence of Copper Sulphate and Manganese Sulphate upon the Growth of Barley." Ann. Bot., 1910. Vol. XXIV, pp. 571-83 ; W. E. Brenchley—" On the Action of Certain Compounds of Zinc, Arsenic, and Boron on the Growth of Plants." Ann Bot. 1914 Vol. XXVIII, pp. 283-301 ; W. E. Brenchley—" Inorganic Plant Poisons and Stimulants" (Cambridge Univ. Press), Second Edition, 1927, pp. 134.

Deficiency of boron also adversely affects nodule production by inhibiting the development of the vascular strands which supply the carbohydrate material needed as a source of energy for the bacteria. The latter become parasitic, attacking the protoplasm of the host cell, and the ultimate result is abnormal nodules which are only capable of fixing very small amounts of nitrogen, less than one-tenth of that fixed in normal plants.

The need for boron was at first thought to be specific to leguminous plants, but it has since been shown to be essential for other species, although the requisite amount may be less. The chemical combination in which it is presented to the plant is immaterial, but no other element, out of over fifty tested, has proved capable of replacing it. Boron deficiency symptoms appear more slowly during spring and autumn than in the summer months, the delay being controlled more by the shorter length of day than by the lower temperatures. The symptoms are similar under both long and short day conditions, though they are less pronounced and their progress is retarded with short days. In no circumstances, however, did shortening the day when boron was supplied produce degeneration effects similar to those induced by a lack of boron. ([6]). Though the need for boron is fully recognised, its function is still undetermined. It may be connected with the uptake or utilisation of other nutrients, but though some indications were obtained of an association between boron and calcium, the evidence was not conclusive and the search continues.

This question of boron deficiency is proving to be one of considerable economic importance, as it is now found that certain obscure "physiological" diseases of important cultivated crops, *e.g.*, heart-rot of sugar beet, brown heart of turnips and certain tobacco diseases, can be cured by the application of from 12-20 lb. of borax per acre. In Sumatra boron compounds take a regular place in the manuring of the tobacco crops, and wherever sugar beet is grown watch is being kept for heart-rot and boron amelioration is being attempted. The subject is being further studied. ([7]).

During recent years much attention has been directed to the importance of these "minor" elements in plant nutrition, and to the possibility of utilising them in agricultural practice for crop improvement. Before this can be done, however, full information on the action of the various elements is needed, and the botanical department endeavours to supply this. Claims are frequently made of heavy crop increases due to the use of certain elements, such as titanium, copper, etc., and these are as far as possible investigated both in soil and water cultures. It seldom happens that the benefit

(6) K. Warington—"The Effect of Boric Acid and Borax on the Broad Bean and certain other Plants." Ann. Bot., 1923, Vol. XXXVII, pp. 629-72 ; K. Warington—"The Changes induced in the Anatomical Structure of *Vicia faba* by the Absence of Boron from the Nutrient Solution." Ann. Bot., 1926, Vol. XL, pp. 27-42 ; W. E. Brenchley and H. G. Thornton—"The Relation between the Development, Structure and Functioning of the Nodules on *Vicia faba*, as influenced by the Presence or Absence of Boron in the Nutrient Medium." Proc. Roy. Soc. B., 1925, Vol. 98, pp. 373-99 ; W. E. Brenchley and K. Warington—"The Rôle of Boron in the Growth of Plants." Ann. Bot., 1927, Vol.XLI, pp. 167-87 ; K. Warington—"The Influence of Length of Day on the Response of Plants to Boron." Ann. Bot., 1933, Vol. XLVII, pp. 429-57.

(7) K. Warington—"Studies in the Absorption of Calcium from Nutrient Solutions, with Special Reference to the Presence or Absence of Boron." Ann. Bot., 1934, Vol. XLVIII, pp 743-76 ; E. Rowe—"A Study of Heart-rot in young sugar beet plants grown in culture solutions." Ann. Bot. (In press).

claimed can be substantiated under experimental conditions, but the possibility always exists, and it is of the greatest importance that all available information shall be obtained on the action of various elements on different types of soil and under different growth conditions.[8].

From time to time an agricultural outlet is sought for by-products in industry. Attempts were made to use iodine compounds (of which there are considerable potential supplies) as a partial sterilisation agent to improve the germination of tomatoes in " sick " soils, and as a preventive of " damping off," but with little or no success. Stronger doses of iodine added to the usual manures were definitely harmful to the germination of barley and mustard, if the seeds were sown directly after treatment. This toxic action gradually decreased and later sown seeds were not affected. Although occasional examples of stimulation were observed in mustard, the results failed to justify any recommendation of an extended use of iodine for agricultural purposes. [9].

The large percentages of silicon present in certain crops, especially cereals, had long attracted attention and suggested that silicon could partially replace phosphorus in the economy of the plant. Experiments in water cultures indicated that under normal conditions of nutrition, with available phosphate present, silicon is ineffective in improving growth, though in the entire absence of phosphate it may produce a slight increase in dry weight. Crops vary in their response to silicate on different types of soil, a certain improvement being obtained chiefly when potash or phosphate is deficient. The benefits, however, were insufficient to justify the addition of silicates to the usual manures.[10]

The action of certain organic compounds on growth has been studied in view of their use as fumigants or sterilising agents. When supplied through the roots, prussic acid and cyanides are extremely poisonous ; 1 part in 100,000 proved fatal to peas, and barley was slightly more resistant, but no sign of stimulation has been observed with any concentration down to 1 part in 1,000,000,000. The phenols behave similarly in their general effects, though the individual substances exert their specific action at somewhat different concentrations. High concentrations are fatal, and somewhat lower strengths have a paralysing effect at first, seriously checking growth for some time. This inhibition gradually wears off, and the affected plants may ultimately make as good growth as the controls. This type of temporary inhibition is rarely seen with inorganic poisons, and may be due to a weakening of the organic toxic material by oxidation or other chemical change. [11]

(8) W. E. Brenchley—" The Action on the Growth of Crops of Small Percentages of certain Metallic Compounds when applied with Ordinary Artificial Fertilisers." J. Agric. Sci., 1932, Vol. XXII, pp. 705-35 ; W. E. Brenchley—" The Effect of Rubidium Sulphate and Palladium Cloride on the Growth of Plants." Ann. Appl. Biol., 1934, Vol. XXI, pp. 398-417 ; W. E. Brenchley —" The Essential Nature of certain Minor Elements for Plant Nutrition." Bot. Rev., 1935. Unpublished work on Copper, Nickel and Cobalt.

(9) W. E. Brenchley—" The Effect of Iodine on Soils and Plants." Ann. Appl. Biol., 1924, Vol. XI, pp. 86-111.

(10) W. E. Brenchley, E. J. Maskell and K. Warington—" The Inter-relation between Silicon and other Elements in Plant Nutrition." Ann. Appl. Biol., 1927, Vol. XIV, pp. 45-82.

(11) W. E. Brenchley—" Organic Plant Poisons. I. Hydrocyanic Acid." Ann. Bot., 1917 Vol. XXXI, pp. 447-56 ; W. E. Brenchley—" Organic Plant Poisons. II. Phenols." Ann. Bot. 1918, Vol. XXXII, pp. 259-78.

Alcohol, absorbed by the roots, is definitely toxic in fairly high concentrations, ethyl alcohol being more poisonous to barley than methyl alcohol. The difference in toxicity is not merely one of degree, but of kind, as with ethyl alcohol ear development was found to begin early, with a corresponding early death of superfluous leaves, whereas with methyl alcohol active vegetative growth continued much longer and ear development was delayed. ([12]). A general review of the resistance of plants to poisons and alkalies, covering a wide field, was recently presented at the Third International Congress for Comparative Pathology at Athens. ([13])

During the course of these inquiries various physiological problems arising out of the methods of technique were studied. Early work with solutions extracted from various Rothamsted soils indicated that within wide limits the rate of growth of a plant varies with the concentration of the nutritive solution, irrespective of the total amount of plant food available. Later on, in standardising the solutions to be used for water cultures, it was again found that the concentration of the nutrient solution, up to a comparatively high strength, has a great effect upon the rate and amount of growth and that starvation effects, due to insufficient nutriment, are obtainable in much stronger concentrations than was usually recognised. ([14])

The harmful effect of overcrowding plants is usually attributed to competition for food and water in a limited area of soil. The importance of aerial competition for light, essential for photosynthesis, was shown by growing barley plants in individual bottles to eliminate competition for food and water, but so closely crowded together that serious shading occurred. The crowded plants suffered drastic reduction in development and ear production, whereas corresponding plants, given ample space, tended to produce a standard type in which the relation between the number of tillers and ears, dry weights, and ratios of root to shoot approximated in some degree to a constant standard.

Although the water culture work is carried on in a roof greenhouse, with minimum interference with the available light, the effective experimental period during the year is limited by light conditions, and as a general rule, few experiments can be carried on during the winter months. On the other hand, cereals fail to grow well if sown too late, and the usual plan is to start cereal experiments during February or March at the latest, and when a later crop is required to utilise other plants, as broad beans or peas, which will develop successfully from summer sowings. Depression of growth during very hot sunny weather was traced to high temperatures at the roots associated with strong and prolonged sunshine, though the two factors acting individually cause much less

(12) A. N. Puri—"Effect of Methyl and Ethyl Alcohol on the Growth of Barley Plants." Ann. Bot., 1924, Vol. XXXVIII, pp. 745-52.

(13) W. E. Brenchley—"The Resistance of Plants to Poisons and Alkalies." Rapp. 3rd Inter. Cong. Pathol. Comp., Athens, 1936, pp. 3-23.

(14) A. D. Hall, W. E. Brenchley and L. M. Underwood—"The Soil Solution and the Minera Constituents of the Soil." J. Agric. Sci., 1914, Vol. VI, pp. 278-301; Phil. Trans. Roy. Soc. B., 1914, Vol. 204, pp. 179-200; W. E. Brenchley—"The Effect of the Concentration of the Nutrient Solution on the Growth of Barley and Wheat in Water Cultures." Ann. Bot., 1916, Vol. XXX, pp. 77-90.

damage. This difficulty was overcome by using sun-blinds and by giving better protection from the direct rays of the sun to the culture bottles, thus keeping the root temperatures at a lower level.[15].

In pot and water culture experiments the ultimate measure of the result is usually that of dry weight, associated with chemical analyses and observations made during growth. The practice has always been to grade the larger seeds used for experiment within close limits of weight, on the assumption that the amount of reserve food in the seed might have an effect upon growth and the final crop. The correctness of this assumption was proved by experiments with peas and barley in which a steady and considerable rise in the dry weight of the plants occurred as the initial weight of the seed increased. Similar results were obtained with either a limited or abundant food supply, and justify the use of large heavy seed for agricultural crops.

With pot cultures the caking of the soil due to surface watering has been overcome by sinking small earthenware pots to their rims in the soil of the experimental pots, and adding the water through the porous pots. Better root development is thus obtained and incidentally much time is saved in watering. [16]

Much of the work of the botanical department is concerned with germination and pot culture tests of manures and other substances requiring investigation, the results of which are frequently incorporated in unpublished reports. With the outbreak of the Great War, fertilisers became increasingly difficult to obtain, and various waste products were examined in the search for substitutes, such as pottery waste, leather waste, flue dust and blast furnace dust containing lead oxide. The conclusion of the War brought a reversal of activities in the attempt to find an outlet for superfluous munitions by converting T.N.T., cordite, etc., into fertilisers and utilising ammonium and potassium perchlorates as weed-killers, as they are too toxic to have manurial value. Germination tests are repeatedly called for, often as a preliminary to further developments if the results prove satisfactory. Large scale pot culture experiments may be carried on for several years before the final report is issued, and frequently a number of soils are imported from various districts in order that tests may be made on different soils under parallel environmental conditions. Superphosphate, mineral phosphate, basic slag, ammonium humate, cyanamide, humunit, sewage sludge, poultry manure, copper sulphate and peat manure are among the substances investigated over a long period, in some cases in association with the chemical department.[17]

The root development of barley and wheat was worked out with

(15) W. E. Brenchley—"Some Factors in Plant Competition." Ann. Appl. Biol., 1919, Vol. VI, pp. 142-70; W. E. Brenchley—"On the Relations between Growth and the Environmental Conditions of Temperature and Bright Sunshine." Ann. Appl. Biol., 1920, Vol. VI, pp. 211-44; W. E. Brenchley and K. Singh—"Effect of High Root Temperature and Excessive Insolation upon Growth." Ann. Appl. Biol., 1922, Vol. IX, pp. 197-209.

(16) W. E. Brenchley—"Effect of Weight of Seed upon the Resulting Crop." Ann. Appl. Biol., 1923, Vol. X, pp. 223-40; K. Singh—"Development of Root System of Wheat in different kinds of soils and with different methods of Watering." Ann. Bot., 1922, Vol. XXXVI, pp. 353-60.

(17) W. E. Brenchley and E. H. Richards—"The Fertilising Value of Sewage Sludges." J. Soc. Chem. Ind., 1920, Vol. XXXIX, pp. 177-82; E. M. Crowther and W. E. Brenchley. "The Fertilising Value and Nitrifiability of Humic Materials prepared from Coal." J. Agric. Sci., 1934, Vol. XXIV, pp. 156-76.

special reference to the "white" roots produced about the time that tillering begins. Their function is probably to provide the plant with a plentiful supply of water and dissolved nutrients at the time that vigorous growth is setting in, abundant root hairs and an enlarged conducting system forming the necessary mechanism.([18])

A further branch of the department's activities deals directly with field problems. The important question of weeds and their eradication led to a series of surveys of arable land to ascertain how far weed species are associated with particular soils or crops, and to what extent they are of general distribution. Comparatively few individual weeds can be regarded as symptomatic of special types of soils, but groups of weeds are characteristic of clay, chalk and peat while loams tend to be colonised by a greater variety. Information on these points is still being collected with the aid of observers in schools and colleges in various parts of the country.([19])

The harmful effect of weeds in crops appears to be due to direct competition for the essential food, water and light, though the possibility of some toxic effect by root excretions cannot altogether be ruled out. Accurate knowledge of the habits of weeds is essential for devising appropriate methods of eradication, and a considerable amount of work has been devoted to this end.([20])

Direct experiments on eradication have been carried out from time to time, the most noteworthy results being the effective use of perchlorate for ridding paths of weeds, and the possibility of utilising thiocyanates for improving very weedy grassland. The latter experiment is still in hand, and promises considerable success. Sodium chlorate is so effective in keeping down weeds that it is now regularly used in the precincts of the laboratories. Special care is needed to avoid splashing boots and clothes with the solution as chlorates are very inflammable if they dry on to organic material.

The difficulties of weed eradication are intensified by the fact that seeds buried in the soil are able to retain their vitality for long periods, often extending over many years. Living seeds of weeds characteristic of arable land were found in areas that had been under grass for varying times (Laboratory House Meadow, 58 years; Barnfield grass, 40 years; Geescroft, 32 years, New Zealand field, 10 years). More than a dozen species germinated, *Atriplex patula* and *Polygonum aviculare* providing the greatest number of

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(18) W. E. Brenchley and V. G. Jackson—"Root Development in Barley and Wheat under different conditions of Growth." Ann. Bot., 1921, Vol. XXXV, pp. 533-56; V. G. Jackson—"Anatomical Structure of the Roots of Barley." Ann. Bot., 1922, Vol. XXXVI, pp. 21-39.

(19) W. E. Brenchley—"The Weeds of Arable Land in Relation to the Soils on which they Grow." I. Ann. Bot., 1911, Vol. XXV, pp. 155-85; "The Weeds of Arable Land in Relation to the Soils on which they Grow." II. Ann. Bot., 1912, Vol. XXVI, pp. 95-109; "The Weeds of Arable Land in Relation to the Soils on which they Grow." III. Ann. Bot., 1913, Vol. XXVII, pp. 141-66; W. E. Brenchley—"Weeds in Relation to Soil." J. Bd. Agric., 1911-12, Vol. XVIII, pp. 18-24; J. Bd. Agric., 1912-13, Vol. XIX, pp. 20-26; J. Bd. Agric., 1913-14, Vol. XX, pp. 198-205; W. E. Brenchley—"Weeds of Farm Land." Longmans, Green & Co., 1920, pp. 239; W. E. Brenchley—"Yellow Rattle as a Weed on Arable Land." J. Bd. Agric., 1912-13, Vol. XIX, pp. 1005-9.

(20) W. E. Brenchley—"The Effect of Weeds upon Cereal Crops." New Phyt., 1917, Vol. XVI, pp. 53-76 W. E. Brenchley—"The Effect of Weeds upon Crop." J. Bd. Agric., 1917-18, Vol. XXIV, pp. 1394-1400; W. E. Brenchley—"Weeds on Arable Land and their Suppression." J. Roy. Agric. Soc. Eng., 1915, Vol. LXXVI pp. 1-24; W. E. Brenchley—"Spraying for Weed Eradication" J Bath and West & Sou. Coun. Soc., 1924-25, Vol. XIX, pp. 1-20; W. E. Brenchley—"Eradication of Weeds by Sprays and Manures." J. Bd. Agric., 1918-19, Vol. XXV, pp. 1474-82; W. E. Brenchley—"West Country Grasslands." J. Bath and West & Sou. Coun. Soc., 1916-17, Vol. XI, pp. 1-28.

individuals.[21] The undue increase of poppies and black bent (*Alopecurus agrestis*) on Broadbalk field led to a two-year fallow, providing opportunity for making a numerical census of the number of viable seeds in the soil before and during treatment, and of following up the after effects of fallowing on the weed flora. Weed species in general show a definite tendency to germinate at a particular season: the majority germinate chiefly in the autumn, but a few, e.g. *Polygonum aviculare* and *Bartsia odontites*, reach their maximum in the spring. This is of great importance in practice, as weeds are most easily destroyed in the seedling stage, and cultivation during the dormant period of the seeds can do nothing towards their eradication. No adequate explanation of the cause of this seasonal effect is forthcoming, though experiments carried out with seeds kept in constant and in fluctuating daily temperatures indicate that temperature conditions are apparently of great, though not of sole, importance. Fallowing operations do not equally reduce all species, as the range of reduction varies over a wide percentage, while a few species may even be increased. This occurs if the interval between cultivations is too long, as some rapidly-growing species are then able to reach maturity and replenish the soil with seeds. The ultimate re-establishment of weed species is not correlated with the degree of reduction by fallowing, but seems to depend upon the rapidity with which any species can begin to reassert itself. *Alopecurus agrestis* and *Stellaria media* were drastically reduced by fallowing, but within three years they were more plentiful than before treatment, whereas *Papaver rhœas* has remained approximately at the fifty per cent. level to which it was reduced by the fallow.[22]

The results of giving weeds a free hand among the crops is well shown by Broadbalk wilderness, in which the wheat crop of 1882 has reverted to an oak-hazel wood where it is entirely undisturbed, and to a rough meadow where the trees and shrubs are removed yearly.[23]

The dominant species in the weed flora of any area are to a great extent determined by the crop and its type of cultivation, winter wheat, spring barley and root crops presenting quite a different balance in their associated weeds. The cumulative effect of long-continued manuring appears to be of secondary importance except in cases of serious deficiency, such as a lack of nitrogen or exhaustion of minerals induced by a prolonged application of ammonium salts only.[24]

Though weeds are generally regarded as pernicious, they have certain beneficent aspects, and during the War search was made for the various uses to which they could be put as substitutes for essential materials that were difficult to obtain. The range of

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(21) W. E. Brenchley—"Buried Weed Seeds." J. Agric. Sci., 1918, Vol. IX, pp. 1-31.

(22) W. E. Brenchley and K. Warington—"The Weed Seed Population of Arable Soil. I." "Numerical Estimation of Viable Seeds and Observations on their Natural Dormancy." J. Ecol. 1930, Vol. XVIII, pp. 235-72; II. "Influence of Crop, Soil and Methods of Cultivation upon the Relative Abundance of Viable Seeds." J. Ecol., 1933, Vol. XXI, pp. 103-27; III. "The Re-establishment of Weed Species after Reduction by Fallowing." J. Ecol. (In Press); K. Warington—"The Effect of Constant and Fluctuating Temperature on the Germination of the Weed Seeds, in Arable Soil." J. Ecol., 1936, Vol. XXIV, pp. 185-204.

(23) W. E. Brenchley and H. Adam—"Re-colonisation of Cultivated Land allowed to revert to Natural Conditions." J. Ecol., 1915, Vol. III, pp. 193-210.

(24) K. Warington—"The Influence of Manuring on the Weed Flora of Arable Land." J. Ecol., 1924, Vol. XII, pp. 111-26.

possible uses is very wide, but in most cases the value is too low or the costs of collection and manufacture are too great for economic exploitation under normal conditions.(25)

Through all these years of change and progress the original botanical work on Park grass was never neglected. Partial analyses of the herbage were made year by year, by Mr. J. J. Willis, till his death in 1911, after which the work was transferred to the botanical department. In 1914 and 1919 complete botanical analyses of every plot were made by a specially recruited staff of assistants, with Miss G. Bassil as deputy supervisor and Mr. E. Gray as referee for knotty points, in view of his long experience of the plots and methods of separation. These results provided a gauge for estimating the change in the herbage since 1877, when Lawes, Gilbert and Masters had completed a series of four quinquennial analyses. They also demonstrated the effects of the system of liming one half of each plot, instituted by Mr. (now Sir) A. D. Hall, in 1903. Complete and partial analyses of specific plots are still made regularly, and a complete synopsis of the results obtained since the experiment was started in 1856 is now available in published form.(26) The serious lodging that occurs on the heavily-manured plots in some seasons and the comparative rigidity of plants supplied with potassium salts led to an anatomical investigation of *Dactylis glomerata*, and the results seemed to point to the rigidity being due to physiological causes rather than to anatomical strengthening.(27) At one period, when frost had devastated the unlimed area receiving heavy dressings of ammonium sulphate, a heavy invasion of fireweed (*Epilobium angustifolium*) occurred, but in succeeding years it failed to hold its ground, and disappeared from the plots.(28)

On the solitary classical plot (Plot 13) receiving organic manures, liming usually proved detrimental to the crop. From 1920 other plots were treated with light and heavy dressings of lime at four-year intervals, and again it appeared that in conjunction with organic manure, or with such combinations of artificials as nitrate of soda and minerals, liming may cause considerable reduction of yield.(29)

The present practice with regard to Park grass is to conduct botanical analyses over a period of years to elucidate some special point in connection with the effect of certain manurial systems. From 1919 to 1934 attention was concentrated on the influence of season upon the botanical composition of the herbage from year to year, in the presence and absence of lime. With complete fertilisers,

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(25) W. E. Brenchley—"Useful Farm Weeds." J. Min. Agric., 1918-19, Vol. XXV, pp. 949-58; W. E. Brenchley—"Uses of Weeds and Wild Plants." Sci. Prog., 1919, Vol. XIV, pp. 121-33; W. E. Brenchley—"Weeds of Farm Land." Longmans, Green & Co., 1920, pp. 187-205.

(26) J. B. Lawes, J. H. Gilbert and M. T. Masters—"Results of Experiments on the Mixed Herbage of Permanent Meadow. II. The Botanical Results." Phil. Trans. Roy. Soc., Part IV, 1882, pp. 1181-1413; W. E. Brenchley—"Manuring of Grass Land for Hay." Longmans, Green & Co., 1924, pp. 146; W. E. Brenchley—"Park Grass Plots." Rothamsted Annual Rep., 1934, pp. 138-159.

(27) O. N. Purvis—"The Effect of Potassium Salts on the Anatomy of *Dactylis glomerata*." J. Agric. Sci., 1919, Vol. IX, pp. 338-65.

(28) W. E. Brenchley and S. G. Heintze—"Colonisation by *Epilobium angustifolium*." J. Ecol., 1933, Vol. XXI, pp. 101-2.

(29) W. E. Brenchley—"Effect of Light and Heavy Dressings of Lime on Grassland." J. Bd. Agric., 1925-6, pp. 504-12; W. E. Brenchley—"The Varying Effect of Lime on Grassland with different Schemes of Manuring." J. Min. Agric., 1925, pp. 504-12.

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including nitrogen and minerals, the relative proportions of the three main groups of species, i.e. grasses, leguminous and miscellaneous plants, are not usually much affected by season, though the individual species vary, but with one-sided fertilisers and on unmanured areas wide fluctuations occur in the percentage of these groups.(30) A new cycle of analyses is now being carried out to determine the effect of potash on the herbage fluctuations from year to year in relation to the supply of nitrogenous fertilisers. The Park grass plots afford a unique opportunity of observing the relations between plant species and seasonal and manurial conditions.

INSECT PESTS AT ROTHAMSTED AND WOBURN, 1935

A. C. Evans

General

A very severe attack of pigmy mangold beetle occurred on Barnfield, the entire crop being lost. Wheat bulb-fly caused much damage on the Alternate Wheat and Fallow and on the Four-Course Rotation experiments. Pigeons completely destroyed the first planting of brussels sprouts on Fosters.

Wheat

Wheat bulb-fly (*Hylemyia coarctata* Fall.) caused much damage on the Alternate Wheat and Fallow and Four Course Rotation experiments, but was slight elsewhere. On Broadbalk, the wheat blossom midges (*Sitodiplosis mosellana* Géhin and *Contarinia tritici* Kirby) are steadily increasing. The following are the figures for the last three years.

	Number of Larvae per 500 ears		
	1933	1934	1935
C. tritici	1,474	3,381	4,289
S. mosellana	319	572	4,221
	Percentage Grain Attack		
C. tritici	0.7	1.5	2.1
S. mosellana	1.4	2.5	18.0

The percentage parasitism found is still low, and so a still further increase in the numbers of the midges is expected in 1936.

Barley

Few gout-fly (*Chlorops taeniopus* Meig.) were present. Several arvæ of a leaf-eating beetle (*Lema melanopa L.*) were found on barley on Hoos field. This species has not yet been recorded in these reports as occurring on the farm.

Oats

A severe attack of eelworm (*Heterodera schachtii* Schmidt) occurred on Long Hoos I. Fortunately the infested area was small.

(30) W. E. Brenchley—" The Influence of Season and of the Application of Lime on the Botanical Composition of Grass Land Herbage." Ann. App. Biol., 1935, Vol. XXII, pp. 183-207.

Kale

Few cabbage aphis (*Brevicoryne brassicae* L.) were present on on this crop on Pastures, but large numbers of flea-beetles (*Phyllotreta* spp.) appeared towards the end of August. However, the plants were well developed and no appreciable damage was done.

Brussels sprouts

The first planting was entirely destroyed by wood-pigeons. Cabbage aphis was plentiful on some plants of the second planting, but a general infestation did not occur.

Sugar Beet

Pigmy mangold beetle (*Atomaria linearis* Steph.) and flea-beetles were present, but no damage was evident.

Beans

Bumble bees (short-tongued *Bombus* spp.) bit through the base of the bean flowers, one hundred per cent. being pierced in this way during June. A species of pollen-eating beetle (*Meligethes aeneus* F.) entered the flower through the hole, laid eggs and several larvæ were usually recovered later from each flower. During July the flowers were not bitten so frequently. It is thought that no damage resulted to the crop.

Mangolds

The crop of mangolds on Barnfield was destroyed by a very severe infestation of pigmy mangold beetle H. F. C. Newton recorded a general attack by this pest on this field during 1934, but in spite of this the resulting crop was better than the fifty-three year average. A survey of all treatments of strips 1, 2, 5, 7 and 8 was undertaken on June 11th. Two samples of soil 12 inches long by 3 inches wide by 3 inches deep were taken at random along the row in each plot. The plant was completely exterminated on the following plots: 1A, 2A, 1N, 2N and 5N, and no beetles at all were found on these plots The remaining plots showed great variation in the size of the plants and the numbers of beetles per sample. In general, the plants were smaller on the A, N and O strips, and larger on the AC and C strips. The concentration of the pest corresponded with the size of the plants. Mr. Newton recorded that in 1934 the beetle was fairly evenly distributed over the field. He took 100 samples and these yielded some 500 beetles. This year 50 samples were taken and these yielded well over 2,000 beetles, the largest number in one sample being 150. The writer only took up his duties on June 1st, and so only the later phases of the infestation were studied. The beetle population, at this late stage of the infestation, was definitely greatest on the rape cake area. In the rape cake area the population was highest on plots 7C and 7AC, lowest on plots 5C and 5AC, and intermediate on the other plots. The seed for the 1936 crop has been treated with a mixture of phenol and magnesium sulphate in an effort to combat the pest.

F

WOBURN

The farm at Woburn was visited on July 13th, but no serious insect damage was seen.

FUNGUS AND OTHER DISEASES AT ROTHAMSTED AND WOBURN, 1935

MARY D. GLYNNE

WHEAT

Three diseases which had not previously been recorded on wheat in this country were found at Rothamsted in 1935.* Of these, *Cercosporella herpotrichoides* Fron. is considered one of the most important of the fungi causing foot-rot of wheat in certain parts of France and of the United States and has recently been recorded in Germany, Holland and Denmark; *Gibellina cerealis* Pass. causes "white straw" disease in wheat and is found in Italy and has recently been recorded in Oregon. *Ophiobolus herpotrichus* (Fr.) Sacc. occurs in several European countries with other fungi causing foot-rot in wheat and is generally regarded as a weak parasite of secondary importance. It has been found on wild grasses, but not previously on cereals in Great Britain and America.

Cercosporella herpotrichoides Fron. was observed in February, causing pale lesions with dark borders on the outer sheaths and leaf bases in Broadbalk and in the adjacent Pennells Piece. Spores were produced abundantly in a few days in the laboratory on material collected in the latter part of March, but hardly any were found in material collected at intervals subsequently. The lesions on sheath and stem were observed till harvest and were abundant among plants which had lodged but were also present on many which had not lodged. The disease was moderate on all Broadbalk plots and on Pennells Piece and was also recorded in certain other fields at Rothamsted.

White Straw Disease (*Gibellina cerealis* Pass.) was found affecting about twenty scattered plants on Hoos alternate wheat and fallow plot. One plant was also found on an adjacent plot of the soil exhaustion experiment.

Ophiobolus herpotrichus (Fr.) Sacc. was found in March in Pennells Piece on wheat stubble which had overwintered in the soil, but no evidence of parasitism was obtained.

Mildew (*Erysiphe graminis* DC.) was noted in February, and by the end of April was unusually plentiful on the nitrogenous manure and Precision experiments on Great Harpenden field. In June and July it was mostly slight or moderate and occasionally plentiful.

Whiteheads (Take-all) (*Ophiobolus graminis* Sacc.). As in many other districts, this disease was unusually common at Rothamsted this year. In Broadbalk it was first noted in March, and by harvest was moderate on several plots, notably the unmanured and that which receives only mineral manure. In Hoos exhaustion experiment, in which manuring has been practically discontinued

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* Glynne, Mary D.—"Some New British Records of Fungi on Wheat. *Cercosporella herpot richoides*, Fron., *Gibellina cerealis* Pass., and *Ophiobolus herpotrichus* (Fr.) Sacc." Trans. Brit. Myc. Soc., 1935, XX, p. 120-122.

since 1901, it was particularly plentiful on those plots in which the previous manurial treatment would seem likely to leave the soil most exhausted. It was present but not plentiful, on a commercial crop grown in rotation on Long Hoos. At Woburn it was slight on the 6-Course rotation and moderate to plentiful on limed and unlimed plots of the alternate wheat and green manure experiment on Stackyard, an eye estimation of the latter suggesting that about 20 to 25 per cent. of the plants were affected. On Lansome, alternate wheat and green manure experiment, it was moderate with bad patches, particularly on the control, and on the old mustard plots which yielded very poor crops.

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

Yellow Rust (*Puccinia glumarum* (Schm.) Ekriss. and Henn.) was first noted in February and in March was moderate, and in some spots plentiful on the Precision wheat on Great Harpenden field, but in spite of its early appearance it did not seem more than usually abundant later in the season. It was slight to moderate on other wheat crops at Rothamsted, and rather less common at Woburn.

Brown Rust (*Puccinia triticina* Erikss.) was slight and occasionally moderate in incidence at Rothamsted, and slight at Woburn.

Foot Rot (*Fusarium* sp.) was occasional at Rothamsted and Woburn.

Leaf Spot (*Septoria Tritici* Desm.) was moderate at the end of January, causing leaf lesions in the alternate wheat and fallow crop on Hoos field and slight or absent in others. In March and April it varied from slight to moderate on other wheat crops at Rothamsted.

Oats

Mildew (*Erysiphe graminis* DC.) varied from slight to plentiful, being most abundant where growth was most luxuriant at Rothamsted.

Crown Rust (*Puccinia Lolii* Niels.) was slight on the commercial oats on Hoos field and moderate on the fumigation experiment on Pastures.

Leaf Spot (*Helminthosporium Avenae.* Eid.) was slight on both crops at Rothamsted. In November it was moderate on self-sown oats on Long Hoos field and was sporing freely. It was also found at the same time in a new crop of oats in the same field.

Barley

Mildew (*Erysiphe graminis* DC.) was moderate to plentiful in the late summer on most of the barley at Rothamsted, and was slight at Woburn.

Net Blotch (*Pyrenophora teres* Drechsl.) was only slight at Rothamsted and was not recorded at Woburn.

Brown Rust (*Puccinia anomala* Rostr.) was plentiful at Rothamsted in the late summer and was not recorded at Woburn.

Leaf Stripe (*Helminthosporium gramineum* Rabenh.) was slight in March on self-sown barley, but was not recorded elsewhere.

Leaf Blotch (*Rhynchosporium Secalis* (Oud.), Davis) which had not been found in 1933 or 1934, though fairly common in previous years, appeared this year in March and April on self-sown barley in a temporary rye grass ley on Hoos field. In the neighbouring continuous barley experiment the disease was fairly plentiful from June onwards, and in the adjacent nitrogenous manure experiment it was very abundant at the side nearest the temporary ley and slight at the opposite side. There was a distinct suggestion that the infection of these two crops may have been chiefly due to wind-borne spores from the self-sown barley in the temporary ley. In other barley crops at Rothamsted and on Stackyard at Woburn the disease was only slight.

RYE

Mildew (*Erysiphe graminis* DC.). A trace was noted on dead lower leaves in July at Rothamsted.

Brown Rust (*Puccinia secalina* Grove) was very slight in July at Rothamsted.

Leaf Blotch (*Rhynchosporium Secalis* (Oud.) Davis) was moderate to plentiful from May to July at Rothamsted. At the end of July it was found only on dead leaves.

GRASS PLOTS

Choke (*Epichloe typhina* (Fr.) Tul.) was a little less common on Agrostis than usual and was rare on Dactylis. This was possibly connected with the fact that 1935 was a " late season " and the stromata of the fungus may not have all been developed. As in previous years, the disease occurred most plentifully on the more acid plots, where also Agrostis was most common. Eggs and larvæ of the dipteron *Anthomyia spreta* Meig. were as usual found on the fungal stroma.

CLOVER

Downy Mildew (*Peronospora Trifoliorum* de Bary) was moderate in June and July at Woburn.

Rot (*Sclerotinia Trifoliorum* Erikss.) was rather plentiful in the winter of 1934 and early part of 1935 on Long Hoos 6-Course rotation and on Pastures field temporary ley. In both experiments bad patches were found on every plot. The disease was checked by frost in February, but patches in which the plants were dead or much damaged remained poor. The crop in Pastures made a better recovery than that in Long Hoos.

LUCERNE

Downy Mildew (*Peronospora Trifoliorum* de Bary) was slight at Woburn from May onwards.

BROAD BEAN

Chocolate Spot, characterised by lesions of limited area, is now regarded as due to *Botrytis* spp., which also causes lesions of unlimited area of the type previously recognised as *Botrytis* spp. Chocolate spot was first observed in the latter part of April on Little Hoos manuring experiment, and on Great Knott in a commercial crop. By the end of June it was plentiful on all plots of the manuring experiment and on the commercial crop, all except the young leaves being attacked. *Botrytis* spp. causing lesions unlimited in area

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varied in the manurial experiment from slight to moderate in plots which had received potash in the fertiliser either as potassium chloride or in dung, and from moderate to plentiful in plots which had received no potash; potash deficiency thus appeared to result in a definite increase in the disease. The fungal attack increased, till by August 1st it was plentiful on all plots. The early attack would, however, be most likely to cause loss in crop. In Great Knott the disease was plentiful by the beginning of July, especially on the lower parts of the plants killing the older leaves and possibly causing considerable reduction in crop.

Rust (*Uromyces Fabae* (Pers.) de Bary) was slight on Little Hoos in mid-July and plentiful in all plots at the beginning of August. None was found on Great Knott in late July.

Aschochyta Fabae Speg. was found on the seeds of the crop from Little Hoos, and was fairly common in October on the leaves of self-sown plants in that field.

POTATO

Virus. Mosaic was slight at Rothamsted and Leaf Curl slight at Rothamsted and Woburn. Streak was moderate at Woburn about 10 per cent. of the plants being affected on Lansome, and about 30 per cent. on Butt Furlong.

Late blight (*Phytophthora infestans* (Mont.) de Bary) was fairly common at Rothamsted at harvest.

Early blight (*Alternaria Solani* (E. and M.) Sorauer, emend. Jones and Grout) was plentiful at harvest on the green leaves producing black patches which produced spores in damp chambers.

MANGOLD

Leaf Scorch (?physiological) and a Virus Mosaic were moderate on Long Hoos continuous cultivation experiment in October.

SUGAR BEET

Virus Mosaic was slight on Long Hoos 6-Course rotation experiment in October.

Crown Gall (*Bacterium tumefaciens* E.F. Sm. and Towns) was found on two or three roots at Rothamsted.

Rust (*Uromyces Betae* (Pers.) Tul.) was moderate in October on Little Hoos field.

Leaf Spot (*Ramularia beticola*) was found on one plant and (*Phyllosticta Betae*) occasionally on Little Hoos field.

Leaf Scorch (?physiological) was moderate on all sugar beet at Rothamsted.

Heart-rot, now ascribed to boron deficiency, was found fairly commonly in certain plots of the "nitrogen manure, spacing and date of sowing" experiment on Little Hoos field. It was more common on the early than on the late sown plots.

KALE

Downy Mildew (*Peronospora parasitica* (Pers.) Tul.) was moderate on a commercial crop in Fosters field, Rothamsted, and plentiful on Lansome field, Woburn, in a crop planted in August.

White Blister (*Cystopus candidus* (Pers.) de Bary) was slight at Rothamsted at the end of January.

CARROT

Violet Root Rot (*Helicobasidium purpureum* (Tul.) Pat.) was found at harvest on a few roots on the experiment on Lansome field.

FARM REPORT, 1935

Weather

The year October, 1934, to September, 1935, was remarkable for the wide variations of rainfall from the monthly averages. Very wet spells alternated with very dry spells throughout the year. October and November were dry; December had an average of more than twice the normal rainfall for the month; January and March were dry, the latter providing 1.5 inches of rainfall below normal; in April the fall was just under 4 inches, twice the normal; late May and early June were very wet, and the early part of August very dry; the September rainfall totalled 4.47 inches, nearly twice the normal for the month. The total rainfall for the year amounted to 30 inches, 1.48 inches above the average.

The winter was abnormally mild, and frosts were almost entirely absent before Christmas. Frosts occurred after Christmas, but were neither severe nor prolonged. The mean temperature for the year was 2°F. above the normal of 48.1°F. In ten of the twelve months the mean temperature was above normal, the outstanding month being December, 1934, with an average of 7°F. above normal. The only two months in which the average was below normal were November, in which month the difference was only 0.1°F., and May, in which month the severe late frost occurred. On the night of May 16th, 1935, an unusually late and severe frost was experienced, 9° of frost being recorded.

In spite of the high average temperature, the total sunshine for the year was 19.4 hours below the 42-year average of 1,562.4 hours. Nine months showed a deficit; the greatest increase was provided by July which, with a total of 280 hours, gave almost 78 hours in excess of the normal.

Weather and Crops

The wet December severely interfered with the sugar beet lifting and prevented any ploughing. The dry January provided the opportunity to get most of the ploughing done, and spring corn-sowing was mainly carried out in March. The heavy rain in May and June made the grass grow ahead of the stock, and several fields, besides those originally shut for hay, were mown. The start of haymaking was delayed until June 21st by rain. Conditions during the making, however, were excellent, and in spite of the lateness in cutting, the hay was of good quality. Usually haymaking and root singling both demand labour at the same time, but this year all singling was finished by the time the cutting commenced.

Harvest commenced on July 31st, 1935, with spring oats. Conditions generally were good, though a wet spell at the end of August delayed the finish of harvest. Stubbles broke up well. The wet September prevented dung carting and interrupted the ploughing for winter corn.

The severe frost on May 16th, 1935, damaged the first-formed flowers of the winter beans and the final yield was reduced. The plants were rather more forward than usual at that date owing to the warm winter and spring, and the effect of the frost was therefore more severe. No damage was done to other crops. Cold winds persisted throughout May and retarded all growth.

The tilth of the winter corn crops was quite firm in spring, there being not sufficient frosts to make the ground puffy.

It was found difficult to prepare a suitable seed bed for the spring oats after sugar beet. The ground was severely puddled during the lifting and carting of the beet in December, and there was little time for frost action between ploughing and sowing.

The year was a favourable one for weeds; charlock, mayweeds and poppies were especially prevalent.

Classical Experiments

Broadbalk was ploughed twice, once immediately after harvest and again shortly before drilling. The plots were drilled on October 23rd, under good conditions. The section fallowed in 1934 showed up during the year by its more luxuriant growth, and every plot on this section and the 1933 fallow section was laid at harvest. Of the other two sections only the dunged plot and the plot receiving the heaviest dressing of sulphate of ammonia were laid. Black Medick and a species of Lathyrus were present in rather larger amounts than usual, especially on certain plots. A few wild oats appeared on the dunged plots but these were hand-pulled before harvest.

The half-acre wheat after fallow was badly attacked for the second successive year by wireworm and wheat bulb fly (*Hylemyia coarctata*). The plant was consequently thin and the yield low.

The plant of wheat on Agdell was rather thin throughout the year and the ground became rather weedy. Coltsfoot (*Tussilago Farfara*) was especially troublesome on the half which grew beans in 1934. The wheat ears were severely damaged by house sparrows during July, and the crop had to be cut and carted before it was fully ripe.

Hoosfield barley plots were drilled with Plumage Archer barley in six-inch rows early in March. Good growth was made throughout the year, and all plots stood well at harvest. Plot differences showed up well this year. The crop was cut and carted under ideal conditions. Threshing took place in January, 1936, and the grain from all plots was bulked and sold for malting. The nitrogen content expressed as the percentage of the dry matter was 1.57 and the calculated extract obtainable from the resulting dry malt was 99.8 per cent. After harvest the stubble was surface ploughed and was worked by harrows at intervals until the winter ploughing.

Ploughing of Barnfield commenced on December 1st, 1934, but was not finished until January 18th, 1935. The field was cultivated and ridged in spring and then worked down for the seed bed. Drilling was done at the end of April but germination was slow and the rows appeared gappy. A survey of the field showed that almost every plant was badly attacked by the Pigmy Mangold Beetle (*Atomaria linearis*). A similar attack was recorded in 1934, but did not destroy the plant. The field was worked as soon as weather conditions allowed and was resown with a mixture of swedes and mustard. A dry spell followed the sowing and only a few isolated plants appeared, even the mustard failing to germinate. The field remained uncropped for the rest of the season but sufficient cultivations were given to keep down weeds. Thistles soon appeared, but there was a remarkable absence of annual weeds. The rain later in August enabled the annual weeds to germinate, the dunged plots being most thickly populated.

The Park Grass plots were severely harrowed in spring and were rolled after the application of manures. The hay was made and carted under good conditions but the yield appeared rather smaller than usual. The second cut was made late in September, the grass being cut and carted in the green state.

The exhaustion land on Great Hoosfield was sown with Victor wheat after barley. Initial growth was quite good, but this was not maintained, the plants later becoming small and stunted with red leaf tips. The old manurial strips which last received manure in 1901 were again noticeable, and the area was harvested according to the old plots. The yield from the two plots which had received dung was very much greater than any other plot.

Modern Long-Term Experiments

Four-Course Rotation. A slight change in the cropping was introduced this year. The seeds mixture, which in past years was undersown in the barley, was replaced by ryegrass sown after the harvesting of the barley and ploughing in of the organic manures. The ryegrass came and grew well during the year, and the yield was good. Some trouble was experienced in ploughing the hard-baked ground after harvest ready for the seeds.

Liming was also introduced, 10 cwt. per acre of ground agricultural lime being applied after potatoes for the barley crop. The potato crop was generally poor, and the yields low, although they were better than in the past two years.

The wheat was the most backward of any on the farm, and appeared quite green on August 1st. It ripened quickly, however, but yields were rather low.

Six-course Rotation. The clover break failed for the fourth successive year, in spite of a very heavy seeding. A good plant was established by autumn, but this disappeared in the spring. The fungus *Sclerotinia trifoliorum* was present but the attack did not seem severe enough to account for the almost total failure of the crop. When the seeding of the barley for the 1936 clover crop was made, the adjacent area was sown with seed inoculated with two different bacterial strains to see if any improvement could be secured by this means.

The break which has in the past been sown with a forage crop was sown this year with rye alone. In 1934 the forage crop was

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harvested as a mature rye crop, owing to the scarcity of tares and beans in this and past years.

Ground agricultural lime is now applied at 10 cwt. per acre to each plot twice in the rotation, before barley and after potatoes. It is hoped this will increase the length of life of the clover plant.

Three-course Rotation (*Straw and Green Manure*). A noticeable feature this year was that the barley plots which were manured in 1934 and had rye ploughed in before the barley were lighter in colour and the plant was smaller. The mean yield of these plots, although good (33 cwt. per acre) was well below that of the other treatments. The depression observed last year from rye ploughed in for beet was not apparent this year. In fact, the beet plots which had rye ploughed in gave the highest yield in 1935.

Three-course Rotation (*Cultivation*). The difficulty found in preparing a suitably clean seed bed for the mangold break after the rotary and tine cultivation mentioned in the 1934 Report appeared again this year. The 1934 wheat stubble quickly became weedy after harvest, and after the spring cultivation these weeds took root again. It was impossible to see the rows until the whole area had been hand-hoed. The two worst weeds were Slender Foxtail (*Alopecurus agrestis*) and Bladder Campion (*Silene inflata*). An autumn cultivation will in future be done on the wheat stubble to prevent this trouble. The mangold seed was treated with magnesium sulphate and phenol as a preventative against Pigmy Mangold Beetle attack. The average yield of approximately 20 tons per acre was lower than the 1934 average but was due to the smothering action of the weeds in the early stages.

The wheat plant was rather thin and the average yield of approximately 21 cwt. per acre was about 2 cwt. per acre lower than in 1934. The barley yields, however, showed a great improvement over last year's figures, this year's average of approximately 34 cwt. per acre being about 8 cwt. higher than in 1934.

Annual Experiments

The number and area of plots under annual and long-term experiments was increased again this year. The number of plots was 875, occupying 18.44 acres. The usual trouble was experienced in obtaining casual labour for singling roots, and when this was obtained the quality of the work was very poor.

Sugar beet. All beet plots were drilled and singled earlier this year. All sowing was done before the end of April and singling by the middle of June. Kleinwanzleben E. seed was used on all annual experiments though Kühn was retained for the rotations. Slight attacks of the Pigmy Mangold Beetle and Flea Beetle were recorded. The beet in the narrow spaced rows looked small and yellow late in summer, and the individual plants were very small. The first sown beet (mid-March) showed a large number of bolters, the actual percentage being as high as 18. This early sowing also provided the highest tonnage of roots per acre, and the greatest weight of sugar per acre. The sugar content of all beet was lower than in 1934.

Potatoes. The potato crop looked poor and backward throughout the year, and on no plot did the haulms meet in the rows. Plot differences, however, were well marked. Lifting of the crop was delayed by weather, but all tubers came up in a clean and sound condition. The produce of each plot was stored separately in the clamp so that the effect of the manures on keeping quality could be determined. Blight was present in small quantities at lifting time.

Brussels sprouts. The setting of the plants was delayed for many days by the high winds which prevented the application of manures. The plants were set on June 5th and 6th, but were immediately attacked by pigeons. Many plants were pulled right out of the ground and others were stripped of foliage. The area was patched in July and the plants watered in. Further damage was done and replacements were needed up to August. Growth was slow throughout the season and several further gaps appeared. The tops were completely stripped by pigeons in December and the sprouts themselves were next attacked, most of them being made unfit for sale. Only two small pickings were made. The germination of weed seedlings was noticeably smaller on these plots which received soot.

Wheat. The experiment on the time of application of nitrogen to wheat again yielded no significant result. The average yield of all plots not receiving nitrogen was 30.7 cwt. per acre, and the average of those receiving nitrogen was 30.6 cwt. per acre. Early in summer those plots which had received nitrogen could be detected by their darker foliage and more forward growth, but this difference disappeared before harvest.

Beans. Certain plots furthest from the farm buildings were somewhat damaged by birds, but on the rest of the area the plants grew well. Damage was done to the early flowers by the late frost, and this may have affected some plots more than others. The plots not receiving potash either in dung or in mineral form made less rapid growth and formed fewer pods. *Botrytis* disease, though present generally, was more severe on the potash-deficient plots.

Temporary Ley in preparation for Wheat. The seeds on the Pastures field plots looked well during the spring and yielded a good first cut. The vetches and mustard sown after the first cut germinated badly and the only plots on which the rows became visible were those which had received the full year's fallow. Even on these plots the germination of mustard was worse than the tares. The green crops were resown after rain late in August, and fair germination resulted. Once again the germination was best on the plots which had received the full year's fallow.

Insect Pest Control. Two investigations on the control and eradication of insect pests were commenced during the year. The piece of Pastures field where the oat crops failed in 1934 owing to attack by the oat eelworm (*Heterodera schachtii*) was treated with fumigants, and oats were again sown. Drilling was late, owing to delay in obtaining the fumigants. The other pest under investigation was wireworm. The piece of grassland between Pastures field and Knott wood was ploughed in late spring, treated with fumigants and sown with sugar beet. In both experiments the fumigants were applied in the plough furrows during the ploughing.

Both crops grew well at the start, but certain plots (Cymag-treated) became very stunted later. The stunted oat plots became thick with may-weed and gave a negligible yield. The beet on the Cymag-treated plots were small and fanged, the roots spreading almost horizontally a few inches below ground-level. The beet on the other plots were normal and the roots of good shape. When both the oat and beet plots were ploughed up after the removal of the crop there was a distinct smell of the fumigants.

Adco. A new method of preparing the straw for Adco was used this year. The barley straw used was soaked for a day in a water tank. After the surplus water had drained off the straw was heaped in layers, and the Adco powder was sprinkled on each layer. The heap was turned only once during the summer. The quality of the resulting product was much better than that produced by the old method of sprinkling the straw with water.

Cropping, 1934-35

Pastures field was dunged for kale this year. Most of the field was dressed in autumn, 1934 and the rest in spring, 1935. The field was drilled with marrow-stemmed kale early in May. The plants came fairly well and little trouble was experienced from the flea-beetle. The field became rather weedy, especially on the site of the 1934 cultivation experiment. The worst weeds were may-weed and iron grass (*Polygonum aviculare*). The plant, although patchy, was fairly thick and grew ahead of the weeds.

Harwood's Piece, the field taken over in 1934 after the purchase of the estate, bore its first crop for several years. It was fallowed in 1934 but drilled with Thousand Head Kale early in May, 1935. Growth was slow throughout the year and charlock and docks were plentiful. Much hand and horse labour had to be expended to keep the field reasonably clean. A small area was dusted with copper sulphate at 20 lb. per acre with quite good results. Most of the kale was folded by sheep during the winter, though about $1\frac{1}{4}$ acres of it were sold for human consumption.

In 1934 the winter beans drilled in Great Harpenden Field were severely damaged by birds, and a very thin and uneven plant resulted. To minimise this damage the beans in Great Knott in 1935 were ploughed in, the beans being placed in the bottom of every second furrow by an attachment fitted to the plough. A rather heavier seeding than normal was given to allow for possible damage. No damage occurred and the crop came up thick and clean. Two harrowings were the only cultivations given and these were sufficient to keep down weeds until the plants met across the rows. The resulting crop gave a large bulk of straw which was poorly podded, partly due to frost killing the flowers and partly to the thickness of plant in the rows. While in the shooks the beans were worried by pigeons. The stubble, which was the cleanest that had been obtained for several years, was grazed by pigs until ploughing.

Fosters was drilled with Plumage Archer barley on two dates, after folded and cut kale. The plant grew well, but the dung applied for the kale, and the folding of sheep, caused much of the crop to be lodged. The yield was good but much grain was lost during harvesting.

Great Harpenden field was drilled with Victor wheat after beans. A top dressing of 1 cwt. of sulphate of ammonia was given in March and a small part of the crop was laid by a thunderstorm shortly before harvest. The crop yielded approximately 28 cwt. per acre. The wheat precision plots and the experiment on the time of application of nitrogen were also situated here. The area immediately surrounding these plots was drilled with Little Joss spring sown wheat. This was badly disturbed by birds and only a thin plant resulted. Linseed was then drilled among the wheat but the mixed crop was again badly damaged by birds just before harvest.

The spring sown Marvellous oats in Long Hoos came well despite the rather rough tilth. A top dressing of sulphate of ammonia was given in March and a good thick plant resulted which stood and yielded well. The crop was harvested under ideal conditions.

The plots of the spring oat variety trial yielded well, the only plot yielding much below the others was the non-Ceresan treated "Marvellous" plot. On this plot the plant appeared later and remained thinner and more weedy throughout the Summer. The following table gives the yields of the different varieties :

Variety.	Yield, cwt. per acre. Grain.	Straw.
Star	33.3	38.8
Marvellous	31.5	39.0
Progress	30.4	39.6
Marvellous (own seed) ..	30.0	36.0
Eagle	29.0	40.6
Golden Rain	27.7	40.3
Marvellous (untreated) ..	23.2	31.3

The northernmost six acres were undersown with seeds but these failed, and after harvest three acres were cultivated up and drilled with rye for spring sheep feed.

Little Hoos was devoted to the annual experiments described elsewhere.

Pennell's Piece was sown with Danish Steel Monarch wheat. The crop was considerably damaged by sparrows just before harvest, and the yield was low.

Grassland

The grass was rather late in commencing growth, but was very productive during the summer. Haymaking, although late, was done under good conditions and yields were good. Those fields not cut for hay were topped during the summer. By mid-August the fields were bare but the grass grew again rapidly in September.

A cultivation and manurial experiment on the improvement of the poor grassland in High Field was laid down during spring. The plots which received the severe harrowing produced far less flowering shoots than did the other plots. The remainder of High Field was severely harrowed in April and sows were out-wintered there.

All other grassland was harrowed and rolled in spring.

Livestock

Pigs. During the third contract period (Jan. 1st-Dec. 31st, 1935), 385 Class I bacon pigs were contracted to be delivered to the factory, and 401 pigs were actually delivered from the two farms. The following table gives the percentage grading returns for the two farms separately :

GRADING RETURNS

(*3rd Contract*)

	Total delivered	Grade A.	Grade B.	Grade C.	Grade D.	Grade E.	Under weight.	Over weight.
Rothamsted *	245	18	25	33	22	less than 1	less than 1	less than 1
Woburn ..	156	24	24	26	22	less than 1	3	less than 1

A third pig experiment in the individual feeding pens was started during the summer. The main comparison was between coarsely and finely ground barley meal ; the effect of exercise on the grading of the bacon was also investigated, full measurements of the carcasses being taken at the factory. The pigs appeared much more healthy than in either of the two previous experiments.

Cattle

Six Shorthorn heifers calved down outside in the spring and remained outside with the calves throughout the summer. Other black polled calves were bought in so that each heifer reared two calves for the first period after calving. After weaning in summer a further calf was fostered on and when this was weaned in autumn the cows were dried off and out-wintered cheaply. The cows were bulled to calve in spring, 1936.

Beef prices remained low throughout the year and even with the subsidy the cattle were not making any more than last year.

Sheep. The 1935 lamb crop averaged about 170 per cent., sixteen sets of triplets being born. The lambs were small at the commencement of lambing but those born later were stronger. Ewe losses were rather heavier than usual.

Prices during the year were rather lower than in the previous year. Those lambs not sold fat off the grass were folded on kale during the winter and sold as they became ready.

Electrical Investigations

A brief account of this work is given on page 69.

Buildings

No major alterations or additions have been made to the buildings, but plans for a new pair of cottages and a new Danish type piggery have been prepared and these buildings will be erected during the coming year.

*The Rothamsted figures include many pigs from the third pig experiment.

Following upon the success of the new method of preparing straw for Adco, plans have been drawn up for a new set of buildings for the making and storing of Adco. The plans also incorporate two cattle feeding boxes so that farmyard manure of known quality can be prepared for experimental purposes.

Show Successes

At the Smithfield Club's Fat Stock Show in 1935, we secured the 6th prize for a bacon pig carcase (160-220 lb. live weight), and were commended for three crossbred fat lambs.

At the Redbourne District Annual Ploughing Match the following awards were gained :

1st Prize.	Best turnout (F. Stokes).
1st ,,	Corn drilling (F. Stokes).
2nd ,,	Best turnout (C. Mepham).
3rd ,,	Horse ploughing (F. Stokes and H. Currant).

The Certificate of the National Horse Breeders' Association and the R.S.P.C.A. Merit Badge were also awarded to F. Stokes.

Implements

We now have at our two farms a large collection of modern farm implements which have either been presented or loaned to us by many of the leading implement manufacturers. They form a source of great interest to the many parties of practical farmers who visit us, and detailed information concerning the quality of their work and their suitability to our land is given when required. The firms who have helped us to make this collection and to whom we are indebted are as follows :

Allen & Simmonds, Ltd.	Motor hoe.
J. Allen & Sons.	Motor scythe.
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.
The Dawewave Wheel Co.	Tractor wheels.
Dunlop Rubber Co., Ltd.	Rubber wheels, paving bricks.
Ford Motor Co., Ltd.	Tractor.
R. G. Garvie & Sons.	Grass seed broadcaster.
General Electric Co.	Electric motors.
Harrison, McGregor & Co., Ltd.	Root pulper, manure distributor.
J. & F. Howard, Ltd.	Ploughs, potato digger.
International Harvester Co., Ltd.	Tractor, drill, manure distributor.
A. Jack & Sons, Ltd.	Root drill and hoe.
L. R. Knapp & Co., Ltd.	Manure and root drill.
R. A. Lister & Co., Ltd.	Oil engine, sheep shearing machine.

Miller Wheels, Ltd.	Tractor wheels.
G. Monro, Ltd.	Motor hoe.
Parmiter & Sons, Ltd.	Rake and harrows.
Ransomes, Sims & Jefferies, Ltd.	Ploughs, cultivators, drills, grass rejuvenator.
Ruston, Hornsby, Ltd.	Grain drill, binder.
Tarpen Syndicate Co., Ltd.	Portable petrol generating equipment.
Transplanters, Ltd.	Robot planter.
J. Wallace & Sons, Ltd.	Manure sower, potato planter.
J. Wilder.	Pitch-pole harrows.
W. A. Wood & Co., Ltd.	Mower, spring tine harrows.

Staff

H. M. Edginton spent about six months here as a voluntary worker to help with the livestock experimental work and field observations. F. R. Russell also spent a short time during the winter helping with general recording and field observations.

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:

> *Temperature 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 anemobiagraph; *Rainfall*—5-inch gauge taken at 9 am. G.M.T.

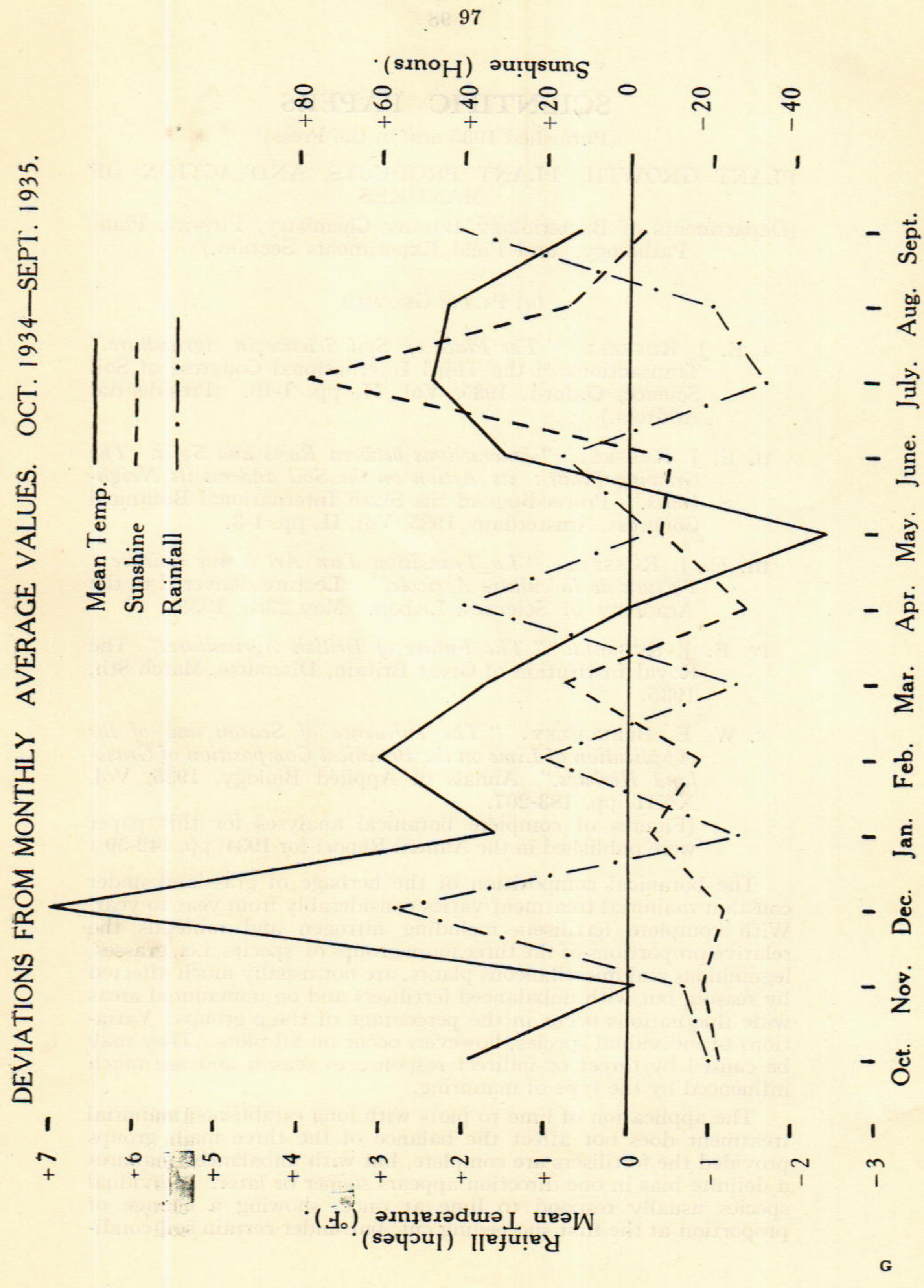
Radiation.—A Callendar Radiation Recorder (on loan from the Imperial College of Science) gives a continuous record of the radiant energy falling on a receiver situated on the roof of the laboratory. The records are compared with those for South Kensington, and are also used in plant physiological studies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

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. The results are discussed on page 68.


DEVIATIONS FROM MONTHLY AVERAGE VALUES. OCT. 1934—SEPT. 1935.
Mean Temp.
Sunshine
Rainfall
Sunshine (Hours).
+80
+60
+40
+20
0
−20
−40
+7
+6
+5
+4
+3
+2
+1
0
−1
−2
−3
Mean temperature (°F.)
Rainfall (Inches)
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May.
June.
July.
Aug.
Sept.

G

SCIENTIFIC PAPERS

(Published 1935 and in the Press)

PLANT GROWTH, PLANT PRODUCTS, AND ACTION OF MANURES

(Departments of Bacteriology, Botany, Chemistry, Physics, Plant Pathology, and Field Experiments Section.)

(*a*) Plant Growth

I. E. J. Russell. "*The Place of Soil Science in Agriculture.*" Transactions of the Third International Congress of Soil Science, Oxford, 1935, Vol. II, pp. 1-10. (Presidential Address.)

II. E. J. Russell. "*Interactions between Roots and Soils. The Growing Plant: its Action on the Soil and on its Neighbours.*" Proceedings of the Sixth International Botanical Congress, Amsterdam, 1935, Vol. II, pp. 1-3.

III. E. J. Russell. "*La Transition d'un Art à une Science: l'Étude de la culture Agricole.*" Lecture delivered to the Academy of Sciences, Lisbon. May 23rd, 1935.

IV. E. J. Russell. "*The Future of British Agriculture.*" The Royal Institution of Great Britain, Discourse, March 8th, 1935.

V. W. E. Brenchley. "*The Influence of Season and of the Application of Lime on the Botanical Composition of Grassland Herbage.*" Annals of Applied Biology, 1935, Vol. XXII, pp. 183-207.
(Figures of complete botanical analyses for this paper were published in the Annual Report for 1934, pp. 142-59.)

The botanical composition of the herbage of grassland under constant manurial treatment varies considerably from year to year. With complete fertilisers including nitrogen and minerals the relative proportions of the three main groups of species, i.e., grasses, leguminous and miscellaneous plants, are not usually much affected by season, but with unbalanced fertilisers and on unmanured areas wide fluctuations occur in the percentage of these groups. Variations of individual species, however, occur on all plots. They may be caused by direct or indirect response to season and are much influenced by the type of manuring.

The application of lime to plots with long established manurial treatment does not affect the balance of the three main groups provided the fertilisers are complete, but with unbalanced manures a definite bias in one direction appears sooner or later. Individual species usually respond to lime at once, showing a change of proportion at the first succeeding cut, but under certain soil conditions a delay may occur until a second dressing has been given. It would appear that the maximum effect of liming is reached within a few years from the first application, after which fluctuations with season may again become more obvious.

Shade is also a factor which influences the balance of species in herbage, some species being more sensitive than others. In general, no correlation can be traced between the annual variations in yield and the botanical composition of the herbage.

VI. W. E. BRENCHLEY. "*The Weed Flora in its Relation to Crop and Agricultural Treatment.*" Proceedings, Zesde Internationaal Botanisch Congres, Amsterdam, 1935, Vol. II, pp. 5-7.

The weed flora of arable land consists largely of plants native to the soil, but the association of species is much modified by cultivation and crop competition, the nature of the competition depending on the type of crop. Root crops help to clean the land on account of the intense cultivation during their growth, while clover, lucerne, and similar plants act as "smother" crops, preventing the development of many weed seedlings. In the case of cereals, the time of sowing, whether autumn or spring, is a principal factor in determining the weed flora.

Rotation of crops is usually the most efficient means of controlling weeds, but sometimes fallowing is necessary, the principle of this being to encourage germination of the weed seeds and, by destroying the seedlings repeatedly, to prevent the formation of fresh seed. Most seeds need a dormant period before they can germinate and the length of dormancy is a vital factor in determining the efficiency of fallowing. Many species also germinate most freely at particular seasons of the year, a fact which decides the time of their greatest vulnerability. For successful fallowing, cultivation must begin directly after harvest and be carried out at sufficiently short intervals to prevent rapidly growing species from ripening fresh seed. Fallowing improves soil fertility, and as weeds and crop alike benefit after-care is important, for the weeds may reassert themselves with extraordinary rapidity.

On old grassland the vegetation itself constitutes the crop, the less desirable species being regarded as weeds. The flora is much influenced by soil fertility, manuring and methods of cultural treatment. Grazing has a direct influence on the weed flora as the various animals eat down the herbage differently, and alternate grazing and taking off crops of hay is a valuable method of weed control.

VII. K. WARINGTON. "*The Effect of Constant and Fluctuating Temperature on the Germination of the Weed Seeds in Arable Soil.*" Journal of Ecology, 1936, Vol. XXIV, pp. 185-204.

Germination of all species was definitely inhibited if the soil was kept in an incubator or cellar where the temperature was practically constant, and light wholly or partially excluded. Some weed seeds were more adversely affected than others, *Alopecurus* *agrestis* being the least and *Papaver rhoeas* the most sensitive of the more important species encountered. Removal of the same samples of soil to a glasshouse after one or two years in the incubator or cellar resulted in a rapid germination of a variety of weed seeds, showing that their failure to appear sooner was due to unfavourable conditions in the previous circumstances. This inhibiting effect on germination is attributed to a lack of sufficient fluctuation in temperature rather than to any reduction in light intensity, though with certain species this may also have played a part. Too long an exposure to the constant temperature resulted in loss of seeds by death, the capacity for survival varying with the different species, *Alopecurus agrestis*, for example, generally failing to survive one year, whereas *Alchemilla arvensis* aud *Papaver rhoeas* remained viable after two years.

VIII. E. M. CROWTHER AND F. CROWTHER. "*Rainfall and Cotton Yields in the Sudan Gezira.*" Proceedings of the Royal Society of London, B., 1935, Vol. CXVIII, pp. 343-370.

The relationships between seasonal yield and weather fluctuations for cotton grown under irrigation in the Sudan Gezira were analysed for periods up to 23 years.

The analysis confirmed the generally recognised bad effects of high rainfall about the period of sowing cotton, but showed that this effect was not universal. An unsuspected but apparently general effect was discovered. Cotton yields were negatively correlated with the amount of early—May and June—rainfall. In some areas yields were negatively correlated with late rainfall and with the total rainfall in the preceding year. The differences between areas in their responses to weather could be partially interpreted in terms of their situations and agricultural histories.

The progressive decline in yield at the oldest trial farm could be largely accounted for by a significant increase in total rainfall during the period of cotton cultivation. The total annual rainfall in the Sudan Gezira exhibited a significant seven-year periodicity, which was reflected in cotton yields, dura exports, and recorded famines. It happened that the first trial of irrigated cotton and the first use of the Sennar Dam coincided with minimal rainfalls on this periodicity. The early promise and rapidly increasing difficulties may well have been due in part to the recurrence of unfavourable weather conditions and not necessarily to soil deterioration and pests.

Uniformly treated record areas could easily be established on a normal commercial basis in irrigation projects under central control, and would provide valuable material for research in agricultural meteorology, and a surer background for determining both experimental and commercial programmes.

IX. E. M. CROWTHER. "*Rainfall and Cotton Yields in the Sudan Gezira.*" Empire Cotton Growing Review, 1936, Vol. XIII, pp. 110-119.

The conclusious from the preceding paper (No. VIII.) were summarised, and extended by testing the rate of change of the rainfall effects with time. In no set of data examined was there evidence that the effect of unit rainfall had increased or decreased significantly over the period of cultivation. It is not, therefore, possible to use the striking agreement between actual and forecasted yields in some of the recent years as support for the view that soil deterioration was being manifested in greater sensitivity to the harmful rainfall.

x. D. J. Watson. "*The Effect of Potassium Chloride on the Diurnal Changes of the Carbohydrates of the Potato Leaf.*" Annals of Botany, **1936**, Vol. L, pp. **59-83**.

The effect of application of potassium chloride on the diurnal changes of carbohydrates in potato leaflets was studied on five plots of the Six-Course Rotation. The changes in composition were all expressed on the basis of 100 gm. initial dry weight, by using a method of sampling which utilises the correlation between opposite leaflets, so that the effect of changes in other constituents was eliminated.

It was found that the rate of formation and removal of starch was not affected, which confirms the work of James and Maskell. The sucrose content was depressed but only during the middle of the day, and there was no effect on reducing sugars.

Significant diurnal variations of starch, sucrose and reducing sugars were found. There was evidence of rapid starch hydrolysis with formation of sucrose at sunset, and of the reverse effect at sunrise.

It has been suggested that "residual dry matter," (dry matter—total carbohydrate) might be used as a constant basis of reference for changes of carbohydrate content. Significant changes of residual dry matter were found, however, during the course of the day, so that this method of expressing the results would have led to erroneous conclusions.

xi. H. G. Thornton and Hugh Nicol. "*Reduction of Nodule Numbers and Growth, produced by the Addition of Sodium Nitrate to Lucerne in Sand Culture.*" Journal of Agricultural Science, **1936**, Vol. XXVI, pp. **173-188**.

A sand culture experiment with inoculated lucerne was made to test the effect of increasing doses of sodium nitrate upon the yield and nitrogen content of tops and roots, and upon the number and development of nodules.

There was no correlation between yield or nitrogen content of the lucerne, and the dose of nitrate.

The number of nodules, though unaffected by 1 gm. of sodium nitrate, was progressively decreased by the stronger doses.

The length of nodules was reduced about 30 per cent. by 1 gm. of sodium nitrate, and decreased progressively with stronger doses.

Nodules were found to show a definite relationship between their overall length and the volume of contained bacterial tissue. Using this relation, the mean volumes of bacterial tissue per nodule and per pot for each series were calculated. The reduction effected by nitrate was far greater when measured in this way, owing to the small contribution of bacterial tissue derived from nodules less than 1.5 mm. in length.

Increasing doses of nitrate also progressively decreased the nodule numbers, and the content of bacterial tissue, per gram of root. The effect of nitrate was thus not due to reduced root growth.

XII. H. G. THORNTON and J. E. RUDORF. "*The Abnormal Structure Induced in Nodules on Lucerne* (Medicago Sativa *L.*) *by the Supply of Sodium Nitrate to the Host Plant.*" Proceedings of the Royal Society of London, B, 1936, Vol. CXX, pp. 240-252.

Lucerne seedlings carrying very young nodules were transplanted into and grown in an agar medium (1) with no nitrate, and (2) containing concentrations of sodium nitrate ranging from 0.05 to 0.2 per cent. The presence of nitrate greatly reduced the growth of the nodules.

The following abnormalities were associated with the supply of nitrate to the host plant :

(1) The cell-walls of the distal cap were very much thickened, the cell-wall material often projecting into the cells in the form of concretion-like lumps. These thickened walls and the lumps gave the same micro-chemical reactions as did the thin cell-walls of the normal tissue. The cell-contents were usually reduced and the nuclei greatly shrunken.

(2) The endodermis that surrounds the central tissue of the nodule and also that which ensheathes the vascular strands were abnormally thickened by a deposition throughout the cell-walls of material giving the suberin reaction.

(3) There was an increased tendency towards necrotic decay of the central bacterial tissue and, where this did not occur, the cell-contents were usually much reduced.

(4) In the younger portions of the bacterial tissue, the bacteria occurred principally in the coccus stage of their life-cycle, a stage usually associated with food deficiency.

XIII. H. G. THORNTON. "*The Action of Sodium Nitrate upon the Infection of Lucerne Root-hairs by Nodule Bacteria.*" Proceedings of the Royal Society of London, B, 1936, Vol. CXIX, pp. 474-492.

The actions of living nodule bacteria and of sterile filtrates containing their secretions were tested upon root-hairs of lucerne grown in agar medium in the presence and absence of sodium nitrate and ammonium sulphate.

Sodium nitrate at initial concentrations of from 0.1 to 1.0 per cent. prevents infection of the root-hairs.

Sodium nitrate at the above concentrations, and ammonium sulphate at a concentration of 0.1 per cent., check the deformation of the root-hairs by the nodule bacteria. This deformation is a necessary prelude to infection and the checking of it accounts for the absence of infection by the nodule bacteria.

Sodium nitrate at a concentration of 0.1 per cent. also checks the deformation of root-hairs by sterile secretions of the nodule bacteria.

Both the living bacteria and their sterile secretions not only cause deformed growth of the root-hairs but in addition stimulate an increase in their number and length. Sodium nitrate also checks this growth-stimulation.

These effects of nitrate in inhibiting the action of the bacterial secretions upon root-hairs are mitigated by the addition of dextrose, together with the nitrate, to the medium surrounding the roots. This suggests that the nitrate interferes with the carbohydrate supply to the piliferous layer of the root.

XIV. L. HAVAS and J. CALDWELL. "*Some Experiments on the Effects of Animal Hormones on Plants.*" Annals of Botany, 1935, Vol. XLIX, pp. 729-748.

Present knowledge on the effect of animal hormones on plants is examined; and experiments described in which a number of glandular extracts was administered to plants. On the whole the effect was small.

XV. J. CALDWELL. "*Occurrence of Copper Poisoning in a Glasshouse Crop.*" Annals of Applied Biology, 1935, Vol. XXII, pp. 465-468.

Small traces of copper may produce in cucumbers a disease simulating virus diseases, and care is necessary in commercial practice to avoid any chance of copper contamination, e.g. in sterilising pots.

(*b*) PLANT PRODUCTS.

XVI. A. G. NORMAN. "*The Hemicelluloses. Part I. Alcoholic Sodium Hydroxide as a Pretreatment to Extraction.*" Biochemical Journal, 1935, Vol. XXIX, pp. 945-952.

As a pretreatment to the preparation or direct determination of hemicelluloses, an extraction of the material with 1 per cent. NaOH in 50 per cent. alcohol has been advocated as a delignifying agent. The effect of various concentrations of alcoholic soda has been studied.

When hot, 1 per cent. NaOH in alcohol concentrations up to 90 per cent. extracts in addition to lignin a considerable amount of polyuronide material, the amount increasing as the alcohol concentration is decreased. When cold, the action is less drastic in 70 per cent. alcohol and higher concentrations, but is still appreciable in 50 per cent. alcohol and lower concentrations. Alcoholic soda is not a very effective delignifying agent in any of these concentrations.

The polyuronide hemicelluloses of different materials vary in the degree of susceptibility to alcoholic soda. Those of immature tissues seem to be more easily removed than those of older lignified materials. No indication has been obtained that the material removed by alcoholic soda represents a special group or type of polyuronide.

XVII. A. G. NORMAN, and (in part) J. G. SHRIKHANDE. "*The Hemicelluloses. Part II. The Association of Hemicelluloses with Lignin.*" Biochemical Journal, **1935**, Vol. XXIX, pp. 2259-2266.

The removal of polyuronide hemicelluloses from plant materials by extraction with hot sulphite solution is affected by previous chlorination to almost the same degree as that of lignin, for which the process was especially designed. Some form of association or combination between lignin and this type of hemicellulose is probable since the extraction of the latter depends on a treatment effecting the solution of the former. Aqueous extractions following chlorination are nearly as effective in the removal of the hemicelluloses as sulphite treatments, once the linkage has been ruptured. The possibility arises that both lignin and hemicellulose may be present in two forms in plant materials, attached and unattached, dependent on the relative quantities of each present.

XVIII. W. T. ASTBURY, R. D. PRESTON, and A. G. NORMAN. "*X-Ray Examination of the Effect of Removing Non-Cellulosic Constituents from Vegetable Fibres.*" Nature, **1935**, Vol. CXXXVI, p. 391.

X-ray studies of the progressive removal of the xylan associated with the cellulosic fibres of manilla hemp support the view that the incorporation of xylan in cellulose is a form of mixed crystallisation. The effect of purification of common fibres by removal of lignin and encrusting hemicelluloses was also studied. Improved definition through sharpening of the crystallite orientation was observed, without reduction of intensity.

XIX. A. G. NORMAN. "*The Composition of Crude Fibre.*" Journal of Agricultural Science, **1935**, Vol. XXV, pp. 529-540.

The determination of crude fibre is one of the oldest of routine agricultural analyses and is widely used in checking the composition of commercial feeds and similar materials. For research purposes or digestibility studies its use may be misleading because the crude fibre fraction obtained does not bear any definite or constant relationship to the structural constituents of the material or to the crude fibre of any other material. The cellulose is partially attacked, and the lignin extensively removed in the process of its isolation. Much variation is found in the lignin contents of crude fibre fractions, highly lignified materials not necessarily yielding a crude fibre high in lignin.

Since the presence of lignin exercises a direct effect on the digestibility of the material, any empirical method of determination of "fibre" should include all the lignin and to achieve this any alkaline treatment must be avoided. Acid hydrolysis may be a possible alternative method, if a correction for protein be made in the case of materials high in nitrogen and the lignin content subsequently determined.

XX. L. W. SAMUEL. "*The Amino-Acid Content of Wheat Flour Dough.*" Biochemical Journal, 1935, Vol. XXIX, pp. 2331-2333.

In an unyeasted flour dough the amino-acid content increased steadily with time.

In a yeasted flour dough the amino-acid content increased slightly for about an hour and then decreased to an almost constant value.

The rate of utilisation of amino-acid by yeast in a solution similar to the dough liquid indicates that in a yeasted dough the protein is decomposed about twice as rapidly as in an unyeasted dough.

XXI. L. W. SAMUEL AND R. K. SCHOFIELD. "*The Binding of Glacial Phosphoric Acid by the Proteins of Wheat Flour.*" Transactions of the Faraday Society, 1936, Vol. XXXII, pp. 760-769.

Making use of the fact that glacial phosphoric acid is a protein precipitant, measurements have been made of the capacity of the proteins of wheat flour to bind this acid by shaking them up with an excess of the acid and determining the amount remaining in solution by back titration on an aliquot.

Solutions of potassium chloride, hydrochloric acid and trichloroacetic acid are slightly diluted by shaking with wheat starch, but there is no appreciable change in the concentration of a solution containing about 8 gm. of glacial phosphoric acid per litre, owing to the balancing of a very small uptake of acid by a "binding" of some water by the starch. The concentration change caused by adding flour is therefore due to acid taken up by the protein.

The capacity of thirty-seven flours to bind glacial phosphoric acid varied from 6.7 to 10.1 milliequivalents per 100 gm. of flour. The uptake tended to be greater for the flours of higher nitrogen content, but the acid bound per gram of nitrogen varied from 3.52 to 4.82.

Although electrometric titrations revealed differences in the proportions of the constituent metaphosphoric acids in different batches of glacial phosphoric acid, determinations of the binding capacity of a gluten with eight different solutions gave a variation of only 5 per cent. between the highest and lowest values.

The uptake per gram of a gluten varied only slightly with the concentration of the acid between 0.02 and 1.0 normal, and was independent of the amount of gluten added, provided not more than a quarter of the acid was removed from the solution. In confirmation of a theory of the molecular structure of the metaphosphoric acids, put forward in an earlier paper (No. LXI, Report for 1934), it has been found that protein removes certain metaphosphate ions from solution in preference to others. It has further been found that different proteins are selective to different degrees showing that their basic groups can be differentiated as regards their action on glacial phosphoric acid.

Reasons are given for thinking that the uptake of trichloroacetic acid by gluten from a 0.5N solution is a measure of its hydrion binding capacity; if so, the additional titratable acid bound (roughly 30 per cent.) when glacial phosphoric acid is used, must be in the form of hydrions associated with polybasic anions.

The lowest pH at which the materials could be washed free of anions (the isoelectric point) was found by Loeb's ferrocyanide method to be: the gluten, pH 6.1; the gliadin, pH 6.85; the glutenin, pH 5.5; and one of the flours, pH 5.95. The pH values were in each case close to those of the materials as procured, and a correction of a few per cent. only had to be applied to the acid uptake to obtain the acid binding capacity.

(c) Action of Manures

XXII. E. M. Crowther (with D. N. McArthur). "*Report on Swede Experiments in* 1934." Appendix II. to Thirteenth Interim Report of Permanent Committee on Basic Slag, Ministry of Agriculture and Fisheries, 1935.

A series of eight 6 x 6 Latin square field experiments on swedes in Scotland was carried out to compare two medium-soluble slags against low- and high-soluble slags and mineral phosphate. At two centres the crops without phosphate failed completely. On the average of the six experiments with highly significant responses low-soluble slag doubled and high-soluble slag trebled the yield. The medium-soluble slags gave intermediate results, but the difference between them was greater than would be expected from their citric acid solubilities.

XXIII. E. M. Crowther and R. G. Warren. "*Report on Field Experiments in England and Pot Culture Work and Laboratory Work at Rothamsted.*" Appendix I to Thirteenth Interim Report of Permanent Committee on Basic Slag, Ministry of Agriculture and Fisheries, 1935.

A series of pot culture experiments on eleven basic slags, including two new medium-soluble slags, showed that the yield of perennial rye-grass and its phosphoric acid uptake followed very closely the amount of citric soluble-phosphoric acid supplied in both single and double dressings of all of the slags. Mineralogical analyses on the ground slags showed that two medium-soluble slags had different assemblages of crystals. One contained the two silicophosphates commonly found in high-soluble slags, and the other contained a new form of silicophosphate. The medium-soluble and the low-soluble slags contained apatite, often intergrown with a calcium silicate.

XXIV. E. M. Crowther. "*The Manuring of Sugar Beet.*" British Sugar Beet Review, 1935, Vol. IX, pp. 71-73 and 105-6.

The results of over 100 manuring experiments on sugar beet during 1928 to 1934 are reviewed and compared with those for similar experiments on potatoes. The sugar beet gave significant responses to nitrogen in half the experiments, to phosphoric acid in one-tenth and to potash in one-fifth. Potatoes were much more responsive, significant effects being obtained in about five-sixths of the experiments with nitrogen and in one-half of those with phosphoric acid and potash.

STATISTICAL METHODS AND RESULTS

(Department of Statistics)

(*a*) TECHNIQUE

XXV. F. YATES. "*Incomplete Latin Squares*." Journal of Agricultural Science, 1936, Vol. XXVI, pp. 301-315.

A description is given of the statistical procedure appropriate for the analysis of a Latin square having missing the whole of one row, one column or one treatment, or one row and one column, or either and a treatment. These are the only types of incomplete Latin squares (except those which can be dealt with by the missing plot technique), of which a neat statistical analysis is possible.

It is shown that incomplete Latin squares of these types give unbiased estimates of error and are therefore valid experimental arrangements. They are consequently likely to be of use when the experimental material is such as to preclude the use of a complete Latin square owing to the fact that numbers in one or both of the natural groups is one less than the number of treatments to be tested.

XXVI. F. YATES. "*A New Method of Arranging Variety Trials involving a Large Number of Varieties*." Journal of Agricultural Science, 1936, Vol. XXVI, pp. 424-455.

A new method of arranging variety trials involving a large number of varieties is described. This type of arrangement, for which the name "pseudo-factorial" arrangement is proposed, enables the block size to be kept small without the use of controls.

Various possible types of pseudo-factorial arrangement are discussed in detail and the necessary formulae developed. The appropriate methods of computation are illustrated by numerical examples based on the results of a uniformity trial on orange trees. It is shown that pseudo-factorial arrangements are likely to be more efficient than arrangements involving the use of controls. In cases where there is considerable soil heterogeneity they are also markedly more efficient than randomised blocks containing all the varieties. In the chosen example gains in efficiency ranging from 26 to 57 per cent. were obtained.

XXVII. F. YATES and I. ZACOPANAY. "*The Estimation of the Efficiency of Sampling, with Special Reference to Sampling for Yield in Cereal Experiments*." Journal of Agricultural Science, 1935, Vol. XXV, pp. 545-577.

The estimation of the yields of the individual plots of replicated experiments on cereals by sampling methods has been practised since the year 1929 at Rothamsted and its associated outside centres.

The present paper contains an investigation of the actual efficiency of the sampling processes adopted in the Rothamsted experiments, as revealed by the sampling and experimental errors. Opportunity is taken to review the theory of sampling errors and their estimation. It is shown that with a given relation between experimental and sampling variation and between the work involved in sampling and in the rest of the experiment there is an optimal percentage of sampling. It is also shown that in many cases there is little to be gained by pushing the sampling beyond certain fairly well-defined limits, even when the work involved in sampling is small.

This discussion is of importance not only in considering the application of sampling to the estimation of yield, but also in all sampling processes performed on replicated experiments. The estimation of plot yields by sampling is an application of only minor importance, since it is always possible, and often simpler, to harvest the whole of each plot; but in many other cases sampling is a vital necessity, and results can be obtained by its aid which could otherwise only be obtained with excessive labour, or not at all. The determination of the necessary amount of sampling in such cases, and the balance between the sampling and the size of the experiment, is a problem which continuously confronts the experimenter. In particular, the individual observation of every plant, of every tree, or of every animal in an experiment, may often prove to be unnecessary when consideration is given to the amount of information obtained.

The paper also contains suggestions for certain modifications of the present sampling procedure for cereal crops. The most important of these (already employed by some workers) is the use of sampling to determine the proportion of grain to total produce on each plot, the yield of total produce being determined by full harvesting. It is shown that this method is capable of greatly reducing the sampling errors with considerably smaller samples than are at present taken, and it seems likely that the method will prove a useful alternative to the present method. The details of an efficient field technique remain to be worked out and tested in practice before it is possible to make a definite assessment of the relative advantages of the two methods.

(*b*) Examination of Results.

XXVIII. W. G. Cochran and D. J. Watson. "*An Experiment on Observers' Bias in the Selection of Shoot-Heights.*" Empire Journal of Experimental Agriculture, 1936, Vol. IV, pp. 69-76.

In this experiment twelve observers were asked to select by eye and measure the heights of two shoots from a quarter-metre of each of 24 rows of wheat, so as to give what they considered a representative sample of the distribution of shoot heights. None of the observers' samples was found to be representative of the population sampled, and their estimates of the mean shoot height were all positively biased. This supports the evidence from other investigations that the only sure method of avoiding bias is for the sampling to be random.

The sampling process actually used in the Wheat Sampling Observations—selection of the two shoots nearest the ends of the quarter-metre—appeared to be satisfactory.

XXIX. W. G. COCHRAN. "*The Statistical Analysis of Field Counts of Diseased Plants*." Supplement to the Journal of the Royal Statistical Society, 1936, Vol. III, pp. 49-67.

The statistical analysis of the data obtained by examining every plant in a field or green-house for disease at certain intervals is discussed. Tests of significance are given, with numerical examples, to detect (1) whether diseased plants tend to congregate in patches scattered over the area or in groups along or across the rows ; (2) whether the distribution of plants recently infected is related to that of plants previously infected ; (3) whether neighbour infection is present.

XXX. W. G. COCHRAN. "*A Note on the Influence of Rainfall on the Yield of Cereals in Relation to Manurial Treatment.*" Journal of Agricultural Science, 1935, Vol. XXV, pp. 510-522.

The study of the effect of rainfall on the yields of wheat from the continuous experiments on Broadbalk, Rothamsted, gave clear evidence of a close relation between the linear response in yield to rainfall and the manurial treatment of the soil. In later investigations of a similar nature on barley at Rothamsted and on wheat and barley at Woburn, the linear effect of rainfall on yield was not significant. This note shows that the relation between seasonal variations in yield and manurial treatment is just as clear at Woburn as on Broadbalk, the difference between the two centres being that similar studies on rainfall effects have had more definite and successful results on Broadbalk. At Woburn, indeed, little progress has been made towards elucidating the particular weather factors whose quantitative influence is important.

For both barley at Woburn and wheat at Rothamsted, which were the cases examined in detail, the grouping of yields according to manurial treatment remained after eliminating the effect of the significant weather factors which were found. This shows that at both centres there are influences, other than rainfall effects of the type examined, whose effect on the seasonal variations in yield is closely associated with manurial treatment.

Some discussion is given of the appropriate test of significance of the difference between two rainfall curves and of a somewhat analogous case which arises in the interpretation of the results of a series of replicated experiments at different centres.

XXXI. M. M. BARNARD. "*An Examination of the Sampling Observations of Wheat of the Crop-Weather Scheme.*" Journal of Agricultural Science, 1936, Vol. XXVI, pp. 456-487.

Sampling observations are now being taken at ten British agricultural stations on each of two standard varieties of wheat. These observations form part of the Crop-Weather scheme spon-

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sored by the Ministry of Agriculture and Fisheries and the Meteorological Office, and their function is to provide information on the influence of meteorological conditions on all stages of the wheat crop's growth from germination to harvest. They also supply information on the connections existing between the different stages of the crop's growth.

The present paper describes a preliminary investigation of the results of the first three years, 1933, 1934 and 1935. The following points have been investigated: (*a*) the length of the interval from the time when the crop is sown until it appears above ground; (*b*) the date at which the crop has twice as many tillers as plants and the rate at which this tillering occurs; (*c*) the maximum number of shoots formed per unit length of drill row; (*d*) the maximum rate of increase of shoot height; (*e*) the yield of grain per acre.

Associations have been found to exist between each one of these quantities, and either specific meteorological factors, or earlier measurements of the crop's progress. In some cases both types of association occur. In the case of the yield of grain, no association with meteorological factors has manifested itself. It would appear, therefore, that such relations are likely to be complex and must await further data for their elucidation.

During the last three years a close connection was found to exist between the yield and the shoot height at ear emergence, greater yields being associated with taller crops. It is probable, therefore, that measurements of the crop's growth, possibly in conjunction with meteorological measurements, will give more reliable predictions of the yield than those obtained from the latter alone. The practical application of this aspect of the results is discussed in Paper No. XXXII below.

XXXII. F. YATES. *"Crop Estimation and Forecasting: Indications on the Sampling Observations on Wheat."* Journal of the Ministry of Agriculture, 1936, Vol. XLIII, pp. 156-162.

The estimation of the yields of agricultural crops, and the forecasting of such yields before harvest, are problems of considerable importance in agriculture, especially since the introduction of a measure of control in agricultural production and marketing. The present paper discusses the forecasting of the yield of the commercial wheat crop about six weeks before harvest by means of simple measurements on the growing crop.

That this is a possibility is indicated by the results of the first three years of the sampling observations on wheat, which were taken at ten stations under the Agricultural Meteorological Scheme. These revealed a very close connection between shoot height at ear emergence and final yield of grain. There was also a slight negative correlation with plant number.

The problem of estimating the yields of commercial crops at harvest by sampling the standing crops is also discussed. Some trial sampling of this type was undertaken by the observers of the Agricultural Meteorological Scheme.

THE SOIL

(Departments of Chemistry and Physics.)

(*a*) Soil Classification.

xxxiii. E. M. Crowther. "*Some Inductive Methods in Pedology.*" Transactions of the Third International Congress of Soil Science, 1935, Vol. I, pp. 339-343.

Three supplementary methods of collecting and analysing soil data are proposed with the object of placing soil classification on a firmer inductive basis.

The collection of local soil names would reveal many natural units which must be accommodated in any general soil classification, and might also show the dominant pedogenic factors. Thus in Great Britain the traditional names emphasise the parent material or the recent geological history, whilst there is a conspicuous absence of names for soils now recognised as belonging to the major world groups.

The genetic interpretation of typical soils might be expressed in terms of a logarithmic time scale analogous to the *p*H scale (i.e. negative logarithms to the base 10 of time in years). Empirical methods of classification and mapping for advisory purposes tend to emphasise local differences and obscure the common factors which become important when the soils are to be linked up with those of other regions. In partially surveyed countries there is a danger that valuable observations may be missed by non-specialists working from crude statements of too restricted genetic theories.

An analysis of the distribution of the soils of the European U.S.S.R. in relation to rainfall and temperature brought out the major characteristics of the Russian soil zones and showed which ones were sufficiently widely and regularly spread to be regarded as in substantial equilibrium with climatic factors, and which were not.

(*b*) Physical Properties.

xxxiv. R. K. Schofield. "*The pF of the Water in Soil.*" Transactions of the Third International Congress of Soil Science, 1935, Vol. II, pp. 37-48.

A treatment of soil moisture relationships based on energy considerations has the advantage that the results obtained are true regardless of the mechanisms at work.

Buckingham's assumption that there is an equilibrium suction for each moisture content does not provide a satisfactory practical basis.

The suction needed to withdraw water from a moist soil is, in general, greater than that against which water will enter the soil at the same moisture content.

In order to deal conveniently with the whole range of suction, use is made of the logarithm of the height in centimetres of the equivalent water (or other liquid) column. The symbol *p*F is used for this quantity.

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The determination of *p*F by direct suction, freezing point, vapour pressure, vertical columns, centrifuge and absorbent materials is considered.

It is shown that by carefully distinguishing wetting from drying conditions the results of investigations on plant wilting and field moisture capacity receive a rational interpretation.

It is suggested that in ordinary soils the difference between the behaviour on wetting and drying is due more to micro-plastic resistance to swelling and shrinking, than to surface-tension effects.

Further lines of enquiry are indicated.

XXXV. R. K. SCHOFIELD and J. V. BOTELHO DA COSTA. "*The Determination of the pF at Permanent Wilting and at the Moisture Equivalent by the Freezing Point Method.*" Transactions of the Third International Congress of Soil Science, **1935**, Vol. I, pp. **6-10**.

Attention is drawn to two defects in the technique of Bouyoucos and McCool for determining the freezing point of moist soil which lead to serious errors.

Results obtained, when due regard is paid to these points, agree well with the best determinations by vapour pressure and seed adsorption, and give the " wetness " of soil at permanent wilting as approximately *p*F **4.2**.

Determinations of the freezing point at the moisture equivalent give values between *p*F **2.5** and *p*F **3.0**. A truly constant figure for all soils is not to be expected.

XXXVI. E. W. RUSSELL. "*The Adsorption of Liquids by Clays.*" Transaction of the Third International Congress of Soil Science, **1935**, Vol. I, pp. **48-50**.

An analysis is made of the factors on which the apparent specific volume (or density) of a clay in different liquids depends.

The results of this analysis are in accord with the hypothesis that clays adsorb non-polar liquids only weakly, if at all ; but that the adsorption of polar liquids is due to the orientation of the electric dipoles in their molecules in the electrostatic fields around the exchangeable ions held by the clay and around the negative charges on the clay substrate.

XXXVII. E. W. RUSSELL. "*The Binding Forces between Clay Particles in a Soil Crumb.*" Transactions of the Third International Congress of Soil Science, **1935**, Vol. I, pp. **26-29**.

The hypothesis is put forward that clay particles are held together in a crumb by orientated molecules of a polar liquid, which was the dispersion medium in the paste from which the crumb was formed. These polar molecules lie between the negative charges on the clay surface and the exchangeable cations that have dissociated from the clay, and they are strongly orientated in the electrostatic field between these charges. The binding link postulated between two clay particles consists of three units : orientated molecules, an exchangeable cation, orientated molecules, and it binds a negative

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charge on the surface of one clay particle to a negative charge on the surface of a second. This hypothesis accounts satisfactorily for the main experimental facts concerning the hardness of crumbs and the conditions under which they are found.

(*c*) Physical Chemistry.

XXXVIII. G. Nagelschmidt. "*On the Lattice Shrinkage and Structure of Montmorillonite.*" Zeitschrift für Kristallographie, A, 1936, Vol. XCIII, pp. 481-487.

A detailed investigation was made of the lattice shrinkage upon dehydration and the structure of montmorillonite, described by Hofmann, Endell and Wilm. The $d_{(001)}$ spacing shows a proportional increase from 10.5 Å to nearly 15 Å during the uptake of the first four molecules of water per $Al_4Si_8(OH)_4O_{20}$, and a slight increase of 0.6 Å during the uptake of the next ten molecules of water. At still higher moisture contents this spacing rises to nearly 19 Å.

These results can be explained by assuming that the first four molecules of water per unit cell enter between the layers of the structure and thus change their distance, whereas the bulk of the next ten molecules of water remains at the surfaces of the crystals.

When water is replaced by methylene iodide or by methyl iodide there is no indication that the liquid takes up definite positions within the lattice.

Some difficulties of explaining these results quantitatively by the detailed structure of montmorillonite are pointed out.

XXXIX. E. M. Crowther and S. G. Heintze, (with D. J. Hissink, Chairman.) "*Report of the Soil Reaction Committee on the Investigation of the Glass Electrode Method.*" Transactions of the Third International Congress of Soil Science, 1935, Vol. I, pp. 128-132.

The glass electrode method was tested on 21 soils at six laboratories and proved satisfactory.

The agreement between the quinhydrone and the glass electrode methods is satisfactory for soils without quinhydrone drift, i.e., for soils which give closely similar potentials about 10 seconds and 60 seconds after adding the quinhydrone. For soils with quinhydrone drift the glass electrode results are similar to those measured by quinhydrone after about 10 seconds. Such rapid measurements by quinhydrone are not reproducible and for soils with large quinhydrone drifts the *p*H values should be measured by the glass electrode.

In order to decide whether the quinhydrone method is appropriate, determinations should always be made rapidly (preferably within 10 seconds) and again after 60 seconds, and the latter readings used when the drift is small.

XL. S. G. Heintze. "*Soil Oxidation-Reduction Potentials and pH Values.*" Soil Research, 1935, Vol. IV, pp. 351-355.

The oxidation-reduction potentials (EH) of the majority of a large number of widely differing soils, measured by four independent workers, tend to follow the *p*H values of the soils. The relationship is similar to that between platinum electrode potentials and *p*H values in buffer solutions. It is suggested that the EH values for most soil-water suspensions are essentially rough *p*H measurements made by a platinum-platinum oxide electrode. EH values may be used to detect acutely reducing conditions in soils but otherwise appear to have little value. A proposal to use EH measurements on acid-treated soils for diagnostic purposes was criticised on the grounds that they include several independent factors which could be separated and measured accurately.

XLI. R. K. SCHOFIELD. "*The Interpenetration of the Diffuse Double Layers Surrounding Soil Particles.*" Transactions of the Third International Congress of Soil Science, 1935, Vol. I, pp. 30-33.

Evidence is set out to show that the simple equation, $x^2=y(y+z)$, for the Donnan membrane equilibrium is not applicable to soils, because the diffuse double layers surrounding neighbouring particles only interpenetrate to a limited extent.

Freezing point measurements of moist $Li^{\cdot}$, $Na^{\cdot}$,$K^{\cdot}$, $Mg^{\cdot\cdot}$, $Ca^{\cdot\cdot}$ and acid-washed soils demonstrate that the interpenetration is less the wetter the soil.

The additional freezing point depression due to ionic dissociation is, broadly speaking, a measure of the repulsive pressure caused by the interpenetration of the diffuse double layers which is liable to destroy the structure of alkali soils.

(*d*) ORGANIC CHEMISTRY

XLII. E. M. CROWTHER. "*First and Second Reports of the Organic Carbon Committee.*" Transactions of the Third International Congress of Soil Science, 1935, Vol. I, pp. 114-127, Vol. III, pp. 82-83.

The reports summarise co-operative work conducted for the International Society of Soil Science and organised from Rothamsted.

Nine soils were analysed for organic carbon by several methods at eleven laboratories. The dry combustion results by a number of methods gave such concordant results that the choice between these methods is probably to be made on the grounds of laboratory convenience. The removal of carbonates by repeated treatment with sulphurous acid solution gave results agreeing with those from separate determinations of total and inorganic carbon. In wet combustions the recoveries of carbon varied with the details of the technique. A number of rapid chromic acid or dichromate titration methods gave useful approximate results when corrected by appropriate factors. Chloride in two of the soils interfered seriously with many of the analyses.

XLIII. ALAN WALKLEY. "*An Examination of Methods for Determining Organic Carbon and Nitrogen in Soils.*" Journal of Agricultural Science, **1935**, Vol. XXV, pp. **598-609.**

The details of the Dennstedt dry-combustion method for determining carbon in soils were described, and some simplifications suggested.

The Bangor modified Kjeldahl method for carbon and nitrogen in soils requires carefully standardised heating. Error may arise from contamination of sandy soils by material abraded during grinding in iron or porcelain mills.

For many heavy soils the addition of water before the Kjeldahl digestion is convenient but not essential. For heavy alkaline soils with little organic matter it is advisable to grind the soil very finely and to add water.

The rapid dichromate titration method of Walkley and Black for soil carbon gave satisfactory approximate results. The details of the technique were improved and methods were devised for overcoming disturbances due to chlorides. The method should be useful in advisory and survey work in which the errors of soil sampling in the field are inevitably high.

MICROBIOLOGY

(Departments of Bacteriology, Chemistry, Fermentation and General Microbiology)

(*a*) BACTERIA

XLIV. C. B. TAYLOR. "*Short-period Fluctuations in the Numbers of Bacterial Cells in Soil.*" Proceedings of the Royal Society of London, B, **1936**, Vol. CXIX, pp. **269-295.**

Significant changes in total bacterial numbers, as counted microscopically by the ratio method, have been shown to take place from day to day, in (*a*) soil freshly taken from the field; (*b*) soil incubated at constant temperature and moisture conditions; (*c*) sterilized and re-inoculated soil incubated at constant temperature and moisture conditions.

Using mannite-salts and soil extract media with the plate count method, significant day-to-day changes in bacterial numbers have been recorded in fresh soil.

Significant changes in bacterial numbers at two-hourly intervals have been obtained in fresh soil by both total and plate count methods.

In fresh soil, fluctuations in bacterial numbers have been correlated with moisture on one occasion only, when intermittent rainfall may have been a limiting factor. In the experiment here described fluctuations were at all times independent of soil temperature changes.

By incubating soil under constant conditions of temperature and moisture it has been shown that the bacterial population may change in spite of those conditions being kept uniform.

There is evidence that fluctuations in total numbers are made up of a series of fluctuations occurring independently in different groups of bacteria.

XLV. H. G. THORNTON and C. B. TAYLOR. "*Short-period Fluctuations in Bacterial Numbers in Soil.*" Transactions of the Third International Congress of Soil Science, 1935, Vol. I, pp. 175-179.

Methods used for the estimation of bacterial numbers in soil fall into two groups, plating methods and microscope counts of bacterial cells in a film of soil suspension. The accuracy of both types of method is discussed. The latter alone can give an absolute figure and has attained a satisfactory degree of accuracy with the development of the "ratio method," which is described. The method is based on obtaining the ratio between counts in a soil film of bacterial cells and of indigo particles, a known number of which have been added to a known mass of the soil.

Both plate and ratio methods show that the bacterial population of soil fluctuates at short intervals during the day and night. These fluctuations are commonly independent of changes in soil moisture or temperature and also take place when soil is kept in an incubator. Their cause is as yet undetermined.

XLVI. H. G. THORNTON. "*The Symbiotic Relationship between Soil Bacteria and Higher Plants, as exemplified by the Leguminosae.*" Transactions of the Third International Congress of Soil Science, 1935, Vol. II, pp. 81-94.

The normally beneficial relationship between the nodule bacteria and their host plant can be disturbed by changes in the physiology of the latter, especially where these lead to a narrowing of the ratio of available carbohydrate to nitrogen in the tissues. Where narrowing is due directly to a shortage of carbohydrate, the bacteria tend to become actively parasitic and to destroy the nodule tissues. Where the ratio is narrowed by excess of inorganic nitrogen uptake, host resistance both to infection of the root-hairs and to growth of the nodule sets in.

Different examples of host resistance are apparently specific to the variety of nodule organism. These include a resistance to infection by nodule bacteria derived from most other legume species. There are also experiments which suggest that nodules produced by one strain may confer an acquired immunity against infection by certain other strains normally capable of infecting the plant in question.

This problem is of special importance owing to the discovery that some strains produce nodules that do not benefit the host plant, owing to causes as yet unexplained.

(*b*) AMOEBAE

XLVII. D. WARD CUTLER and L. M. CRUMP. "*The Effect of Bacterial Products on Amoebic Growth.*" Journal of Experimental Biology, 1935, Vol. XII, pp. 52-58.

The two common soil amoebae *Hartmanella hyalina* and

Naegleria gruberi were grown in pure culture with the addition of filtrates from bacterial cultures, and also with the filtrate derived from a suspension of crushed bacterial cells. Filtrates prepared from young cultures of two bacteria, both of which could be used as food by the amoebae, were without effect on *H. hyalina*; a filtrate prepared from the crushed cells of *B. mycoides* inhibited reproduction in *N. gruberi*, and also hastened the onset of cyst formation.

(c) Biological Activities

XLVIII. C. N. Acharya. "*Studies on the Anaerobic Decomposition of Plant Materials. IV. The Decomposition of Plant Substances of Varying Composition.*" Biochemical Journal, 1935, Vol. XXIX, pp. 1459-1467.

In the anaerobic decomposition of oat, wheat, rice and barley straws, bracken leaves, young grass mowings and rape seed cake, it was found that in all cases the chief decomposition products were acetic and butyric acid, CH_4 and CO_2. The materials richer in nitrogen yielded more butyric acid and CH_4. Addition of nitrogen had only a slight stimulating effect on the decomposition of materials of low nitrogen content (e.g., straw). Hemicellulose and to a less extent cellulose was decomposed, whilst lignin appeared to remain unchanged. Lignin has a marked inhibiting effect on the decomposition of protein and other constituents.

XLIX. S. H. Jenkins. "*The Biological Oxidation of Carbohydrates. V. The Decomposition of Cellulose in the Activated Sludge Process and in Percolating Filters.*" Biochemical Journal, 1936, Vol. XXX, pp. 497-505.

Cellulose is one of the constituents of sewage and trade effluents which decomposes readily under anaerobic conditions with the formation of methane. As little is known about its rate of decomposition in the aerobic processes used for purifying sewage, suspensions of pulp cellulose were added to an activated sludge and the rate of decomposition under different conditions found when air was blown through the mixture. In another experiment the cellulose was passed through biological filters. Contrary to expectations, as much cellulose disappeared in the activated sludge process when the C/N ratio in the mixtures supplied was 80/1 as when it was 8/1. But in the filtration experiments 10 per cent. more cellulose was oxidised with the lower ratios. The results showed that the amount of N used by micro-organisms decomposing cellulose may vary within wide limits depending upon the amount of N supplied. Thus, by providing plenty of N in the filtration experiments, for every 100 parts of C decomposed 4.3 of N were used; with a small supply, 100 of C used 1 of N; while Hutchinson and Richards found that for straw to decompose properly the initial requirement of 100 parts of C was 2.5 of N.

L. N. W. Barritt. "*The Treatment and Disposal of Milk Factory Effluents. I. By Means of Percolating Filters and Septic Tanks.*" Journal of the Society of Chemical Industry, 1936, Vol LV, pp. 48T-54T.

Milk factory effluents equivalent in strength to 1 per cent. of fresh milk contain the organic and inorganic substances required for bacterial growth and in this respect are suitable for treatment by biological oxidation in percolating filters. Mechanical separation of the fat, however, with its accumulation in the filter, inhibits its own oxidation and causes clogging of the filter, resulting in a low rate of purification. This effect appears to be associated with an abnormal growth of fungi.

Preliminary treatment in a septic tank brings about separation of fat, and thus avoids this difficulty in subsequent treatment on a percolating filter. A rapid lactic acid fermentation also occurs, the effect of which depends on the buffer capacity of the salts in solution. With distilled water containing 1 per cent. of milk the reaction of the liquid falls below *p*H 4.6 (the isoelectric point of casein) and causes precipitation of casein and inhibition of proteolysis. When hard tap water is used the *p*H of the liquid may not fall below 5.5 ; the casein then remains in solution and undergoes digestion by proteolysis. Such a liquid is quite suitable for treatment on a percolating filter at a rate of 100 gallons per cubic yard per day and leaves behind a tank sludge of low nitrogen content.

The use of alkali in the wash waters also favours proteolysis in the storage tank, but the addition of waste waters containing sugar will result in abnormally high acidities and may cause precipitation of casein even in solutions of high buffer capacity. Such tank effluents, especially if of high biochemical oxygen demand, have wide C/N ratio and would not be particularly suitable for treatment on a percolating filter without addition of available nitrogen and probably also of phosphates.

LI. A. G. Norman. "*The Decomposition of Lignin in Plant Materials.*" Transactions of the Third International Congress of Soil Science, Oxford, 1935, Vol. III, pp. 105-108.

Knowledge of the defects in the determination of lignin have permitted conclusions as to the availability of lignin to be placed on a surer basis. The determination of lignin is affected by the presence of pentose units and proteins unless special precautions be taken. Determinations made on decomposing materials are apt to be misleading because pentose-containing constituents are progressively removed and microbial protein concurrently synthesised. When these disturbing factors are taken into account it may be shown that lignin under aerobic conditions is slowly but steadily fermented. Over 40 per cent. and probably more than 50 per cent. of the lignin of oat straw was removed in twelve months.

LII. H. L. RICHARDSON. "*The Nitrogen Cycle in Grassland Soils.*" Transactions of the Third International Congress of Soil Science, 1935, Vol. I, pp. 219-221.

In normal grassland soils the equilibrium levels of ammonia and nitrogen are low, the level of ammonia being consistently above that of nitrate. These equilibrium values show no clear seasonal changes or effects of long-continued manurial treatments. They are rapidly restored after the addition of nitrogenous fertilisers. Added ammonia nitrogen appears to be absorbed by the herbage no less rapidly than nitrate nitrogen. Incubation experiments on soil from the Park Grass plots showed that the amount of mineralisable nitrogen rose to a maximum in early spring and fell to a minimum in late summer, unless the summer were unusually dry.

THE PLANT IN DISEASE: CONTROL OF DISEASE

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

(*a*) INSECTS AND THEIR CONTROL

LIII. C. B. WILLIAMS and P. S. MILNE. "*A Mechanical Insect Trap.*" Bulletin of Entomological Research, 1935, Vol. XXVI, pp. 543-551.

The trap consists of two nets in the mouth of which are electric fans which blow a current of air and the insects therein into the nets. The arm bearing the two nets revolves slowly and the level can be altered.

LIV. C. B. WILLIAMS and F. J. KILLINGTON. "*Hemerobiidae and Chrysopidae (Neur.) in a Light Trap at Rothamsted Experimental Station.*" Transactions of the Society for British Entomology, 1935, Vol. II, pp. 145-150.

A list of the species of two families of Neuroptera captured in the light trap together with an analysis of their sexes, times of appearance during the year and times of flight during the night.

LV. C. B. WILLIAMS, "*The Times of Activity of Certain Nocturnal Insects, chiefly Lepidoptera, as indicated by a Light Trap.*" Transactions of the Royal Entomological Society of London, 1935, Vol LXXXIII, pp. 523-555.

The paper contains a description of the light trap with its bottle-changing mechanism which enables the insects to be sorted according to the time of night that they enter the trap. Tabulations are given showing the time of flight at night of about eighty species of Lepidoptera, as well as some species of other orders and also certain families and orders. The results obtained in two years are shown to be very similar.

LVI. C. B. WILLIAMS. "*Further Evidence for the Migration of Butterflies.*" Bulletin de la Société Royale Entomologique d'Egypte, 1935, pp. 250-261.

A collection of about thirty records of directional movements of butterflies in various parts of the world published as evidence of migration.

LVII. H. F. BARNES. "*On the Gall Midges Injurious to the Cultivation of Willows.* II. *The So-called 'Shot Hole' Gall Midges* (Rhabdophaga *spp*)." Annals of Applied Biology, 1935, Vol. XXII, pp. 86-105.

Previous workers assumed that only one species of gall midge was responsible for " shot hole " damage on willows. In this paper four species, three of which are described for the first time, are recognised. Their bionomics have been worked out. All the species reproduced by means of unisexual families while three of them are single brooded, the remaining species having two broods a year. All the species are restricted to one species of cultivated willow. Certain parasites which attack the midges are recorded.

LVIII. H. F. BARNES. "*Studies of Fluctuations in Insect Populations. IV. The Arabis Midge,* Dasyneura arabis (*Cecidomyidae*)." Journal of Animal Ecology, 1935, Vol. IV, pp. 119-126.

The bionomics of this species are given. The dates of emergence and the number of generations during the period 1928-34 have shown the constancy with which the minor variations caused by differences in weather conditions become levelled out by the end of each year. Delayed fertilisation of the females is shown to send up the numbers of males in the ensuing family. In addition as the season advances the percentage of males decreases.

LIX. H. F. BARNES. "*Studies of Fluctuations in Insect Populations. V. The Leaf-curling Pear Midge,* Dasyneura pyri (*Cecidomyidae*)." Journal of Animal Ecology, 1935, Vol. IV, pp. 244-253.

The dates of emergence and number of generations of this species during the period of 1928-1933 are given. A limitation of generations by the length of the season in which new growth can be found on pear trees is suggested. The parasite *Misocyclops marchali* is recorded as attacking the second and ensuing generations of the midge but in no case the first generation of the year. The sex ratios of the various generations of the midge varies, as the season advances so the percentage of males increases. This is exactly the reverse of what happens in *Dasyneura arabis* (see Paper No LVIII). This can be explained on the hypothesis that the further developed the eggs are at the time of entry of the sperm the more males result.

LX. H. F. BARNES. "*Studies of Fluctuations in Insect Populations. VI. Discussion on Results of Studies I-V.*" Journal of Animal Ecology, 1935, Vol. IV, pp. 254-263.

Additional data on the wheat blossom midges and the button top midge of willows brings the published information complete up to 1935. It is shown that the major fluctuations in numbers of gall midges are caused by the action of weather on the insect, the host plant, and the insects' parasites. The whole series of studies is discussed from this view point.

LXI. J. MARSHALL. "*The Location of Olfactory Receptors in Insects : a Review of Experimental Evidence.*" Transactions of the Royal Entomological Society of London, 1935, Vol. LXXXIII, pp. 49-72.

LXII. J. MARSHALL. "*On the Sensitivity of the Chemoreceptors on the Antenna and Fore-tarsus of the Honey-bee,* Apis mellifica L." Journal of Experimental Biology, 1935, Vol XII, pp. 17-26.

LXIII. H. L. A. TARR. "*Studies on European Foul Brood o Bees. I. A Description of Strains of* Bacillus alvei *obtained from different Sources and of another Species occurring in Larvae affcted with this Disease.*" Annals of Applied Biology, 1935, Vol. XXII, pp. 709-718.

Strains of *Bacillus alvei* from four countries have been studied in detail, and certain differences were found with respect to the ability of these organisms to produce acid from a series of fermentable carbon compounds. It has been suggested that these variations might form a basis for differentiating strains of this organism. The characteristics of another spore forming bacillus which appears to take the place of *B. Alvei* in certain cases of European foul brood have been described in detail. The various theories which have been presented in an attempt to explain the etiology of this disease are briefly discussed.

LXIV. F. TATTERSFIELD and J. T. MARTIN. "*The Problem of the Evaluation of Rotenone-containing Plants.* 1. Derris Elliptica *and* Derris Malaccensis." Annals of Applied Biology, 1935, Vol. XXII, pp. 578-605.

Seven samples of *Derris* root have been examined chemically, and the following determinations carried out : rotenone (crude and and recrystallised), ether extract, methoxyl content, and dehydro compounds. The importance of using standard methods of analysis is stressed.

Insecticide tests have been carried out and comparisons made between pairs of samples tested on the same day.

When comparisons were made between pairs belonging to different species of *Derris*, the determinations of rotenone by the present methods, ether extract or methoxyl content did not express accurately the relative insecticidal potencies of the pairs of samples. When comparisons were made between pairs of the same species, all these determinations appeared to give a closer measure of their relative activities.

The estimation of the dehydro compounds, or of rotenone plus the dehydro compounds in the resin, gave a better assessment of the relative potencies than the other determinations, whether comparisons were made between samples of the same, or of different species. Further work on other samples is, however, needed.

LXV. F. TATTERSFIELD. "*Fish-Poison Plants as Insecticides. A Review of Recent Work.*" The Empire Journal of Experimental Agriculture, 1936, Vol. IV, pp. 136-144.

The insecticidal importance of the various crystalline derivatives isolated from fish-poison plants, and the difficulties met with in the chemical evaluation of these insecticidal plants are briefly discussed. The relative importance of several species of *Derris*, *Lonchocarpus*, and *Tephrosia* is discussed.

(*b*) VIRUS DISEASES.

LXVI. J. CALDWELL. "*Physiology of Virus Diseases in Plants. VII. Experiments on Purifications of the Virus of Yellow Mosaic of Tomato.*" Annals of Applied Biology, 1935, Vol. XXII, pp. 60-85.

Purification by Vinson and Petre's method, slightly modified, gave an infective material that always contained organic nitrogen, and was active over a *p*H range from 2.0 to 10.5 ; but there was no evidence that the virus could be recovered pure in crystalline form. Various methods used to purify the virus still further are described.

LXVII. J. CALDWELL. "*On the Interaction of Two Strains of a Plant Virus. Experiments on Induced Immunity in Plants.*" Proceedings of the Royal Society, B, 1935, Vol. CXVII, pp. 120-139.

Two strains of the Yellow Mosaic Virus of tomato have been isolated, of which one, although not apparently an attenuated form of the other, immunises host plants against the second. The types of interaction which may occur when two viruses are present simultaneously in the one host are discussed and differentiated.

LXVIII. G. SAMUEL, R. J. BEST and J. G. BALD. "*Further Studies on Quantitative Methods with Two Plant Viruses.*" Annals of Applied Biology, 1935, Vol. XXII, pp. 508-524.

The arrangement of experiments for the comparison of several virus samples is discussed and suitable methods suggested. The amount of inoculum, provided enough is used to cover the eaf, does not affect the number of lesions produced by the spatula technique ; but the conditions to which test plants were subjected shortly before inoculation had a considerable effect. The *p*H and electrolyte content of the inocula influence the number of lesions. The optimum *p*H for tomato spotted wilt is from 6.0—8.5, for tobacco mosaic (with concentration 0.05—0.2 M) about 7.0. The influence of oxidising and reducing agents on the virus of spotted wilt is further discussed.

LXIX. M. A. HAMILTON. "*Further Experiments on the Artificial Feeding of* Myzus persicae (*Sulz*)." Annals of Applied Biology, 1935, Vol. XXII, pp. 243-258.

A method is described for the feeding of *M. persicae* on media containing a radioactive indicator. By this means it was shown that *M. persicae* picks up the indicator from the medium and transmits to a leaf, on which it is fed later, a constant proportion of the amount imbibed. Evidence is given to show that the virus probably behaves as does the radioactive indicator.

(c) Fungus Diseases.

LXX. M. D. Glynne. "*Incidence of Take-all on Wheat and Barley on Experimental Plots at Woburn.*" Annals of Applied Biology, 1935, Vol. XXII, pp. 225-235.

Surveys made in 1931, 1932 and 1933 of the incidence of Take-all, *Ophiobolus graminis* Sacc. in the continuous wheat and barley manurial experiments at Woburn Experimental Station showed the disease was present in varying amount in most plots ; the percentage being usually higher in wheat than in barley and little or no disease occurring in plots with a *p*H value of 5 or less. In wheat Take-all appeared to increase in each plot until 35 per cent. of the plants were infected and then to decrease.

TECHNICAL AND OTHER PAPERS

GENERAL.

LXXI. E. J. Russell. "*Jacob G. Lipman and Soil Science.*" Soil Science, 1935, Vol. 40, pp. 3-7.

LXXII. R. K. Schofield and G. W. Scott Blair. "*The Infuence of the Proximity of a Solid Wall on the Consistency of Viscous and Plastic Materials.*" Journal of Physical Chemistry, 1935, Vol. XXXIX, pp. 973-981.

Measurements have been made of the rate of flow of an aqueous paste of barium sulphate through tubes differing considerably both in radius and length under a series of pressure heads. The results show that for tubes of the same radius and under the same pressure gradient, the rate of flow is independent of the length of the tube ; from which it is concluded that under the conditions of these experiments, this material shows no progressive breakdown with time under shear, as suggested by Ambrose and Loomis for bentonite.

For different radii, however, curves for $V/\pi R^3$ against $PR/2L$ were obtained which, as previously recorded, do not coincide as they should if at every point in the tube the velocity gradient depends only on the shearing stress.

The hypothesis previously advanced that the proximity of the wall of the tube causes a sheath of material to shear more easily than does the bulk of the material, appears therefore to be the only one at present that accounts for the facts.

The case of this barium sulphate paste is particularly interesting, as the particles are roughly cubical in form, and the thickness of the modified layer is many times the average particle diameter.

LXXIII. C. B. Williams and G. A. Emery. "*A Photographic Moonlight Recorder.*" Journal of Scientific Instruments, 1935, Vol. XII, pp. 111-115.

An apparatus in which a cylindrical lens produces a line image of the moon on a strip of photographic paper. The lens is moved by clockwork to follow the moon's apparent movement across the sky and the sensitised strip is darkened when the moon is shining. The apparatus can also be used, with some adjustments, as a sunshine recorder.

LXXIV. W. G. COCHRAN: "*Recent Advances in Mathematical Statistics* 1934." Journal of the Royal Statistical Society, 1936, Vol. XCIV, pp.

The sections contributed to this review cover papers dealing with moments and semi-invariants of sampling distributions, orthogonal polynomial theory and the analysis of variance.

LXXV. C. N. ACHARYA. "*Structure and Oxidation of Nitrogenous Substances.*" Nature, 1935, Vol. CXXXVI, p. 644.

LXXVI. M. D. GLYNNE and H. V. GARNER. "*Research at Rothamsted of Importance in Horticulture.*" Scientific Horticulture, 1935, Vol. III, pp. 215-221.

CROPS, SOILS AND FERTILISERS.

LXXVII. E. J. RUSSELL. "*Soils and Fertilisers.*" The Farmer's Guide to Agricultural Research in 1934. Royal Agricultural Society of England, 1935, pp. 185-223.

LXXVIII. F. YATES and W. G. COCHRAN. "*Sampling Observations on Wheat.*" Journal of the Ministry of Agriculture, 1935, Vol. XLI, pp. 1152-4; Vol. XLII, pp. 211-4, pp. 528-31, pp. 642-4.

LXXIX. HUGH NICOL. "*Leguminous and Mixed Cropping: Some Important Consequences.*" The Fertiliser, Feeding Stuff and Farm Supplies Journal, 1935, Vol. XX, pp. 550-552.

LXXX. E. W. RUSSELL. "*Physical Description of Soil Tilth.*" Sands, Clays and Minerals, 1936, Vol. II, pp. 57-71.

LXXXI. E. M. CROWTHER." *Soil Analysis and Manuring.*" Sugar Beet Annual, 1936, The Lincolnshire Sugar Company Ltd., 1936, pp. 33-43.

LXXXII. E. M. CROWTHER. "*Soils and Fertilisers.*" Reports on the Progress of Applied Chemistry, 1935, Vol. XX, pp. 536-573.

LXXXIII. H. H. MANN. "*Tea Soils.*" Imperial Bureau of Soil Science, Technical Communication No. 32, 1935, pp. 1-64.

LXXXIV. H. V. GARNER. "*The Choice of Phosphates for Grass Land.*" Journal of the British Dairy Farmers' Association, 1935, Vol. XLVII, pp. 25-34.

LXXXV. E. H. RICHARDS. "*The Manurial Value of Sewage Sludge.*" Journal of the Ministry of Agriculture, 1935, Vol. XLII, p. 737.

BIOLOGICAL.

LXXXVI. A. G. NORMAN. "*The Biological Decomposition of Lignin.*" Science Progress, 1936, pp. 442-456.

The decomposability of lignin is one of the most controversial subjects in microbiology because the experimental evidence is so contradictory. It has, however, been shown that owing to the difficulties attached to the accurate determination of lignin, the problem is really one of biochemistry. The evidence on decomposition has been collected and re-examined in the light of the analytical methods used and their known deficiencies. In this way inconsistencies can be explained and the conclusion drawn that lignin *in situ* is slowly decomposed under aerobic and anaerobic conditions. Isolated lignin, however, appears to be unavailable.

LXXXVII. A. G. NORMAN. "*Fungi for Food.*" Food Manufacture, 1935, Vol. X. pp. 130-132.

LXXXVIII. E. BARTON-WRIGHT, D. WARD CUTLER and L. M. CRUMP. "*Contamination in Petri Dish Boxes.*" Nature, 1936, Vol. CXXXVII, p. 110,

LXXXIX. C. B. WILLIAMS. "*Immigration of Insects into the British Isles.*" Nature. 1935, Vol. CXXXV, pp. 9-10.

XC. C. B. WILLIAMS. "*Immigration of Butterflies in Britain.*" Discovery. 1935, Vol. XVI, pp. 36-39.

XCI. C. B. WILLIAMS. "*A Mass Flight of the Cabbage White Fly.*" Entomologist. 1935, Vol. LXVIII, pp. 218-219.

XCII. H. F. BARNES. "*Some new Coccid-eating Gall Midges* (Cecidomyidae)." Bulletin of Entomological Research, 1935, Vol. XXVI, pp. 525-530.

The following species are described for the first time—*Dentifibula lacciferi* whose larvae are predaceous on *Laccifer javanus* in Malaya; *Coccodiplosis citri* predaceous on *Pseudococcus citri* in Pretoria; *Schizobremia coffeae* from mealy bugs on coffee in Uganda and Tanganyika Territory; and *Schizobremia jujubae* from *Pseudococcus* on *Zizyphus jujuba* in Mauritius.

XCIII. H. F. BARNES. "*Recent Advances in Entomology.*" Science Progress, 1935, Vol. XXIX, pp. 510-517.

XCIV. H. F. BARNES. "*Recent Advances in Entomology.*" Science Progress, 1935, Vol. XXX, pp. 115-123.

XCV. H. F. BARNES. "*Lavender Pests.*" Journal of the Royal Horticultural Society, 1935, Vol. LX, pp. 113-118.

XCVI. H. F. BARNES. "*Notes on the Timothy Grass Flies* (Amaurosoma *spp.*)." Annals of Applied Biology, 1935, Vol. XXII, pp. 259-266.

XCVII. H. F. BARNES. "*Two Gall Midges on* Erica arborea, *including the Description of One New Species* (*Cecidomyidae*)." Bulletin de la Société d' Histoire Naturelle de l' Afrique du Nord, 1935, Vol. XXVI, pp. 139-141.

XCVIII. H. L. A. TARR. "*The Brood Diseases of Bees.*" Report of the Lectures given at the Fifteenth Midland and South Western Counties Convention of Bee-keepers, 1935, pp. 21-31.

XCIX. H. L. A. TARR. "*A Note Concerning the Brood Disease Investigation at Rothamsted Experimental Station.*" Year Book of the South-Eastern Federation of Bee-keeping Associations, 1935, pp. 5-7.

C. H. L. A. TARR. "*Brood Diseases of Bees.*" Bee-keeping, 1935, Vol. I, pp. 115-123 and pp. 142-146, 1936, Vol. II, pp. 37-41.

CI. H. L. A. TARR. "*Abridged Report of the Foul Brood Investigation for September 30th, 1934 to September 30th 1935.*" Bee World, 1936, Vol. XVII, pp. 8-12. (Also in Bee Craft and British Bee Journal).

CII. H. L. A. TARR. "*The Organism of European Foul Brood of Bees.*" Nature, 1936, Vol. CXXXVII, pp. 151-152.

CIII. H. L. A. TARR. "*A Note Regarding* Streptococcus apis Maassen." Bee World, 1936, Vol. XVII, p. 19, (also in Bee Craft and British Bee Journal).

CIV. H. L. A. TARR. "Bacillus alvei *and* Bacillus para-alvei." Bee World, 1936, Vol. XVII, pp. 43-45, (also in Bee Craft and British Bee Journal).

CV. K. GRANT. "*Records of Butterfly and Moth Migration, 1931-1934.*" South-Eastern Naturalist and Antiquary for 1935, Vol. XL, pp. 52-56.

CVI. A. C. EVANS. "*Physiological Races of* Lucilia Sericata, *Mg.*" Nature, 1936, Vol. CXXXVII, pp. 33-34.

WOBURN EXPERIMENTAL FARM
REPORT FOR 1934-35

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

The season was one of very variable nature, commencing with a severe thunderstorm in September, 1934; rainfall in October and November was rather above the average, and very heavy in December, reaching 4.5 inches in that month, there being 25 rainy days. The winter, however, was mild, and there was but little frost; there was only one fall of snow all the winter. January 1935, was dry, February wet, but March was again dry, so that spring sowing could be done well.

May was marked by cold winds, followed by a "dripping" June, 20 wet days being recorded, though the total rainfall was only 1.95 inches. In July and August hot and very dry weather followed and brought on the ripening of the corn crops so that an early harvest was obtained, and got in in good condition, it being possible to thresh the small experimental corn crops in the field. September, October, and November were all wet—the total rainfall for 1935 being 26.13 inches as against 19.56 for the previous year.

The meteorological records for 1934-5 were as follows:

METEOROLOGICAL RECORDS. 1934-5

Month.	*Rainfall.* Total Fall.	No. of Rainy Days.	Bright Sun-shine	*Temperature (Mean)* Max.	Min.	1 ft. in Ground.	Grass Min.
1934—	Ins.	No.	Hours.	°F.	°F.	°F.	°F.
Oct. ..	1.67	18	91.1	57.3	45.2	51.6	40.6
Nov. ..	1.94	13	43.0	47.0	37.9	43.1	33.9
Dec. ..	4.56	25	21.0	49.9	42.1	45.1	37.0
1935 —							
Jan. ..	0.77	10	36.1	43.8	35.4	40.7	31.0
Feb. ..	2.75	17	49.1	47.2	36.3	41.2	33.0
Mar. ..	0.41	8	130.4	50.5	35.9	43.1	31.5
April ..	2.98	20	125.9	53.0	38.7	46.6	34.0
May ..	2.41	9	188.2	59.1	40.5	53.7	37.8
June ..	1.95	20	200.0	67.3	50.8	60.7	48.2
July ..	0.52	5	244.9	75.0	52.0	68.8	48.4
Aug. ..	2.09	10	202.4	74.1	51.5	67.5	47.4
Sept. ..	3.98	17	151.7	64.2	48.6	57.1	45.9
Oct. ..	2.84	18	107.5	55.8	42.2	49.4	38.4
Nov. ..	3.48	20	62.0	49.4	39.1	44.6	35.5
Dec. ..	1.95	19	32.4	41.5	32.7	37.9	29.6
Total or mean for 1935 ..	26.13	173	1530.6	56.7	42.0	50.9	38.4

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CONTINUOUS GROWING OF WHEAT AND BARLEY

Stackyard Field, 1935, 59th Year (no manure since 1926.) The fallowing operations on both these plots, begun in 1934, were continued throughout 1935, a vigorous attempt being made to free the land of weeds by cultivation. In this, considerable success was obtained, so much so, indeed, that in the autumn of 1935 these plots were considered fit to put again in corn. In this connection it may be said that continual cultivation and stirring of the fallow land resulted in eliminating the twitch (mainly *Holcus mollis* and *Agrostis stolonifera*) and getting rid of a good deal of *polygonum aviculare* (hogweed) ; fallowing alone was, however, quite ineffective in reducing materially either mayweed or spurry. It was noticeable, nevertheless, that on the acid plots no mayweed would thrive, though spurry was thick.

After the two years' fallowing, wheat (" Red Standard ") was again sown on October 24th, 1935, and barley will follow in spring 1936, on the land formerly occupied by that crop. In neither case has any fresh manuring been done, the last applications having been made in 1926.

ROTATION EXPERIMENTS

The Unexhausted Manurial Value of Cake and Corn (Stackyard Field) 1935.

Series C.

Twelve tons per acre of the swede crop of 1934 were fed off by sheep, these receiving (*a*) on the cake-fed plot ,15 cwt. of mixed linseed and cotton cake giving 78.3 lb. of nitrogen per acre ; (*b*) on the corn-fed plot 15 cwt. of a mixture of oats, barley and wheat, supplying 26.5 lb. of nitrogen per acre. There was, thus, considerable difference in nitrogen between the two sets.

Barley (" Plumage Archer ") was drilled early in March, and came up well. Towards the end of March Alsike clover was sown among the barley. The barley crop was cut on August 7th, stooked, carted to the farm, and threshed in January, 1936. The yields were as follows :

Plot.	*Head Corn.*		*Tail Corn.*	*Straw Chaff, etc.*		
	Bushels.	Weight per Bushel. lb.	lb.	cwt.	qr.	lb.
1. After Cake-feeding	38.7	55.7	15	24	0	16
2. After Corn-feeding	32.5	55.9	5	20	2	16

The crop was quite a good one, tail corn being but small in amount. The cake plot, as usual, gave the higher return by 6.2 bushels per acre, yet it is remarkable that the corn plot, which received additionally only 26 lb. per acre of nitrogen in the four years' rotation, gave so good a result and one so nearly approaching the yield from the higher application (78.3 lb. acre) of nitrogen by the cake-feeding.

Series D.

The Alsike clover left after the barley crop of 1934 had been removed, had not been good and, though the parts where it was thin had been resown, the crop was poor and "clover sickness" made its appearance over a considerable part of the area. A good deal of damage was also done by pheasants and other birds. Early in May, 1935, the clover was lightly mown over in order to get rid of seeding weeds, and in the comparatively cold and wet weather of May and June the clover seemed to recover somewhat and began to grow again. It was finally cut on July 5th and made into hay, the weights being :

	Yield of Clover Hay per acre		
Plot.	cwt.	qrs.	lb.
1. After Cake-feeding	12	2	24
2. After Corn-feeding	14	3	16

The difference in weight in favour of the corn plot was really due to the amount of plant left after the attack of "clover sickness," rather than to any difference of manuring.

Green Manuring Experiment

Stackyard Field, 1935 (*Series A*)

(*a*) *Upper Part—Wheat after Green-crops*

The first green crops—Mustard and Tares—of 1934 had been fed off by sheep which received also 1½ cwt. per acre of cotton cake, this giving 7.6 lb. of nitrogen per acre. The mustard crop supplied 20.2 lb. of nitrogen per acre, the tares crop, 44.4 lb. A second green-crop of each kind was sown in August but, owing to drought, came to little and, not being enough to feed off, was ploughed in. The total amounts of nitrogen supplied by the two several green-crops and the cake addition were : Mustard plot, 37.4 lb. per acre ; Tares plot, 58.3 lb. per acre.

The land was prepared for wheat in October and this ("Red Standard") was drilled on November 6th, 1934.

Up to the beginning of May, 1935, the wheat grew quite well, that after tares looking rather the better. After this, however, the change that has so often before been noticed on these plots showed itself, the wheat plant turning yellow and but a poor crop was the result. Rabbits also did a great deal of damage, but by taking, for weighing, the less injured portions, the following will fairly represent the result :—

YIELD OF WHEAT PER ACRE. 1935.

Plot.	*Head Corn.*		*Tail Corn.*	*Straw, Chaff, etc.*
	Bushels.	Weight per Bushel.		
		lb.	lb.	lb.
Tares (unlimed) ..	12.3	63.2	14.0	1066
Mustard (unlimed)	9.9	63.4	9.0	799

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The limed plots were too much damaged for the weights to be satisfactorily recorded.

It may be observed that these plots followed the usual sequence of being quite promising at first and then failing badly in May, and finally yielding only meagre crops of wheat.

(*b*) (*Lower part*). *Green-crops after Wheat.*

After the wheat crop of 1934 green-crops of mustard and tares were sown—the latter in April, 1935, and the former in May. In neither case was anything but a very poor crop obtained, and, these not being enough to be fed off with sheep, were ploughed into the land. It was intended to take a second crop of each, but these could not, owing to the continued drought, be put in in time for getting wheat in afterwards, and the consequence was that the wheat crop for 1936 had to be sown with only the addition ot nitrogen from the small first green-crops.

Lansome Field. Green-manuring Experiment, 1935. *Wheat after Green-crops.*

After the green-crops of 1934 had been turned in, wheat (" Red Standard ") was drilled on November 2nd—the mustard crops had supplied 40.6 lb. of nitrogen per acre, the tares 97.2 lb. Already in March the wheat had begun to turn yellow and by May this was much worse, so that—as on Stackyard Field—only small yields of wheat were obtained, as shown in the following Table :—

YIELD OF WHEAT PER ACRE. 1935.

Plots.	*Head Corn.*		*Tail Corn.*	*Straw, Chaff, etc.*
	Bushels.	Weight per Bushel.		
		lb.	lb.	lb.
1. Mustard, old series..	10.9	59.5	10½	1560
2. Tares, old series	16.9	61.1	12¼	2737
3. Mustard, new series	11.2	62.2	10½	1870
4. Tares, new series	11.7	62.7	8	2079
5. Control, new series..	9.6	61.5	16¼	1696½

As in Stackyard Field, the wheat crop after tares was rather the better, but the crop, considering the amount of nitrogen supplied to it in the green-crops, was miserably poor.

Lucerne. Inoculation Experiment—Lansome Field, 1935.

This experiment, on the advantage or otherwise of inoculating the seed before sowing it, had been started in the year 1932, and so was now in its fourth year. The plots had yielded two cuttings in 1932 and in 1933, but three were obtained in 1934. Now, again, in 1935, three crops were reaped. After the 1934 crop the plots were harrowed and 10 tons per acre of farmyard manure were applied, this being the first manurial treatment since the first sowing of lucerne. The lucerne, though in its fourth year, continued to thrive and gave a wonderfully good and clean crop at each time of cutting. There were 12 plots, one half of these having been originally sown with inoculated seed and the other half with seed not so inoculated. The averages of the two sets, each composed of 6 plots, when reckoned as green lucerne or as lucerne hay were as follows:—

	Green Produce per acre.	Lucerne Hay per acre.
	tons.	tons.
Uninoculated area	25.6	6.55
Inoculated area	25.2	6.48

There was thus—as in former years—nothing to favour the inoculation of the seed, but it was remarkable, indeed, that such a yield as shown above should have been reached in the fourth year of the growing of lucerne, and that without the use of any manure, until 1934—5, when they received 10 tons of farmyard manure per acre. Up to the present, and including the 1935 crops, the total yields have been :—

	Lucerne Hay per acre.
	tons.
Uninoculated area	14.60
Inoculated area	14.24

The hay of the inoculated plots was, throughout, rather the higher in nitrogen.

Taking the total crops of the four years, the following amounts of nitrogen were obtained in the crops and removed from the land :—

	Nitrogen per acre
	lb.
Uninoculated area (4 years) ..	791.14
Inoculated area (4 years) ..	826.68

Grass Experiments. Broad Mead, 1935.

These experiments on the manuring of grass land were commenced in Broad Mead in 1901. They comprised six different plots, one with lime, one with farmyard manure, and the others with different artificial manures. In 1935 the plots were grazed by sheep and were much improved by the close feeding they received.

Pot-Culture Experiments.

The remainder of the earlier work undertaken at Woburn is comprised in the investigations carried out at the Pot-culture

Station. These have direct reference to problems which have arisen out of the field experiments; among the principal are (*a*) green-manuring, (*b*) acid soils, (*c*) clover-sickness.

Rotation Experiments. Series B. Stackyard Field, **1935.**

This was a series commenced in 1932 under the new Rothamsted plan. The rotation is a six-course one, the respective crops being, in 1935, red clover; wheat; barley; rye; sugar beet; potatoes. Of these all came well with the exception of red clover, which was unaccountably poor, for there was no "clover-sickness" here.

Miscellaneous Experiments.

In Lansome Field different strains of lucerne are being grown, also carrots (manurial experiment), Green-manuring experiment using lupins and then turning these into the land before planting kale. The growing of Soya-bean is also tried and has been fairly successful.

In Butt Close a very extended manurial experiment on sugar beet was carried out, this involving investigations as to time of planting and distance of drills apart. Other work covered the growing of different varieties of wheat, the time of application of sulphate of ammonia, etc.

In Great Hill Pyrethrum continued to be successfully grown, and in Warren Field plots laid down in different grass mixtures in 1931 were kept under observation. In 1935 they were grazed by cattle and sheep.

All the above, including Series B (rotation), form part of the new Rothamsted work and will be separately reported on from there.

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WOBURN FARM

REPORT FOR 1935 by J. R. MOFFATT

The weather during the year 1934-35 was generally favourable to farm work. The winter was unusually mild, very few severe frosts occuring. Both autumn and spring sowing periods were dry and crops went in under good conditions. The grassland remained very green during the winter and though growth was slow early in spring the grassland was very productive throughout the summer. Hay was made under satisfactory conditions and yields were quite good.

Stackyard field permanent wheat and fallow plots were fallowed again this year. Barley after folded swedes in Series C went in well and looked well throughout the season. The seeds undersown in this barley and under the rotation barley for the 1936 crop were sown shortly after the corn was drilled. This early sowing was very successful as both areas had a very good plant after harvest. The 1935 clover crops in both Series D and the rotation were poor and patchy and yields were very low.

The wheat on the farm, although looking poor early in the summer, filled out well later and gave high yields. The yield of the plots on the time of application of nitrogen experiment in Butt Close was 25.3 cwt. per acre for the no nitrogen plots and 31.0 cwt. per acre for those plots receiving nitrogen. The yield of the wheat plots on the six course rotation in Stackyard field was also well above the average. Barley yields, however, were not so good as last year.

The root crops were very disappointing, all giving much smaller yields than usual. The germination of sugar beet was slow and growth seemed checked throughout the summer. The plant recovered to some extent by making late growth but yields were very much below the average. In Butt Close the average yield of the plots was 12 tons of washed beet per acre compared with the 1934 average of over 18 tons per acre. The sugar content averaged under 16per cent. compared with the 1934 figure of over 17 per cent. The yield of carrots was also much below last year's figure. The kale crop was quite satisfactory.

The potato crop looked quite well and clean throughout the year although many plants showed symptoms of virus disease. The usual Dunbar Cavalier variety was replaced this year by Majestic as there was no ready market for the former variety. Yields of both experimental and commercial crops were lower than usual and many of the tubers were rather misshapen. The tubers came up rather wet and selling commenced immediately.

Livestock

The lambing was carried out successfully, the final percentage being almost 170. Five sets of triplets were born, three of which were run as such. As at Rothamsted the early born lambs were rather small. The lambs were sold fat off the grass during summer and winter and were all sold by the new year.

The Large White Gilts purchased in 1934 have done well and have provided us with sufficient gilts to maintain a herd of this breed. A few Large Black sows are being retained but the crossbred sows are being sold fat as they age. The bacon factory grading returns are given on page 93.

Thirty Irish cattle were purchased in the autumn, the best of which will be sold fat during the winter and the remainder fattened on grass during the summer.

Show Successes

We were successful in obtaining the first prize for fat lambs at the 1934 Bedford Christmas Show, and at the Ampthill Show in July we secured a first prize for a crossbred gilt, 2nd prize for a purebred gilt, 3rd prize for fat lambs, and reserve for an in-pig sow.

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DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, WOBURN, 1935

(The Cultivations and Manurings of the replicated experiments are given in the appropriate Yield Tables.)

Field	Crop	Variety	Principal Cultivations and Dates	Sowing Dates	Cutting or Raising Dates	Carting Dates	Manuring per Acre	Yield per Acre
I. *Arable* Butt Close	Sugar beet	Klein-wanzleben	Feb. 1-2, 1934—Tractor plough after potatoes; Mar. 8—Tractor cultivate; Mar. 13—Harrow; Mar. 20—Springtine harrow; April 15—Harrow; April 24—Drill seed 20 lbs. per acre and flat roll; May 17—Horse hoe; May 22—Start bunching; June 3—Start singling; June 13—Finish singling; June 19, July 25—Horse hoe; July 24-30—Hand hoe	April 24	Oct. 24—Nov. 5. (Tops fed to cattle)	—	—	10 tons
Butt Furlong (1)	Kale	Marrow-stem and Thousand headed	Feb. 28—Mar. 3—Plough in dung Mar. 13—Cambridge roll; Mar. 21—Cross-cultivate; Cambridge roll; Mar. 23—Drill $\frac{3}{4}$ acre M-S Kale and roll; Apl. 30 and May 7—Horse hoe; May 7—Drill 2nd strip M-S Kale and roll; May 14—Horse hoe first plant; May 21—Hand-hoe; May 22-24—Horse-hoe; May 27—Harrow; May 30—Cambridge roll, 2nd planting Kale; June 11—Drill 3rd strip with T-H Kale and roll; June 24—Horse hoe all Kale; June 29—Drill last strip with T-H Kale and roll; July 10 and 24—Horse hoe 3rd and 4th strips Kale.	*Marrow-stem* Mar. 23 May 7 *Thousand headed* June 11 June 29	Cut as required during winter and spring for feeding to stock	—	Farmyard manure 25 tons per acre (Feb. 1-28) Sulphate of Ammonia 1st strip—1 cwt., May 14. Whole area—1½ cwt., Aug. 3.	20 tons
Butt Furlong (2)	Potatoes	Majestic	(As for Kale to Mar. 21). Mar. 25-26—Bout up for potatoes; Apl. 2-3—Plant potatoes, 25 cwt. per acre and cover; Apl. 27—Harrow down; May 11-13—Bout up; May 17-18—Horse hoe May 27—Harrow down; June 6 Bout up	April 2-3	Oct. 7-15	Pitted in field	Farmyard manure 25 tons per acre (Feb. 1-28)	8 tons

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, WOBURN, 1935 (*Continued*)

Field	Crop	Variety	Principal Cultivations and Dates	Sowing Dates	Cutting or Raising Dates	Carting Dates	Manuring per Acre	Yield per Acre
Lansome Piece (1)	Potatoes	Majestic and Ally	Mar. 15-20—Plough, after Kale; Mar. 21—Cambridge roll; Mar. 27—Bout up; Apl. 3—Plant 1st lot potatoes and cover, and Apl. 29—pull down ridges; Apl. 30—Plant 2nd lot potatoes and cover; May 3—Plough for 3rd planting; May 14—Harrow, roll and bout up; May 16—Plant 3rd lot potatoes and cover; May 22—Horse-hoe; May 27—Harrow down; June 5—Bout up; June 11—Harrow down; June 17—Horse-hoe all lots; June 24-25—Bout up	Apl. 3 April 30 May 16	Oct. 16-24	Pitted in field	—	8 tons
Lansome Piece (2)	Lucerne	Provence	(Planted in 1932). Nov. 30, 1934—Harrow three times; Dec. 8, 24, 31, 1934—Harrow 3 times on each date; Jan. 5—Harrow 3 times; Jan. 16—Harrow 6 times; Jan. 19—Harrow 3 times Mar. 18—Harrow	(Planted in 1932)	July 3-4 Aug. 16 Nov. 18	Carted green at once	Farmyard manure 10 tons per acre Jan. 22, 1935	25 tons green forage
Stackyard Field	Permanent Wheat Permanent Barley	Fallow Fallow	Nov. 30—Dec. 12, 1930—Tractor plough; Mar. 22—Tractor-cultivate and harrow; Mar. 26—Tractor-cultivate; Mar. 28 and 30—Tractor-harrow and roll; May 13 and 22—Tractor-cultivate; June 28 and July 2 Tractor-cultivate and harrow; Sept. 19-27—Tractor plough	—	—	—	—	—
Stackyard Field Series A	Wheat	Red Standard	Oct. 12-16, 1934—Plough; Oct. 27—Cross roll; Mar. 6-10—Harrow; Mar. 20—Flat roll; Mar. 25—Harrow; Apl. 15, Apl. 29, May 2—Harrow; May 8—Cross harrow	Nov. 6, 1934	Aug. 15	Aug. 22	Tares and Mustard fed off with 1½ cwt. cake or corn per acre	11 bush. (average)

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, WOBURN, 1935 (*Continued*)

Field	Crop	Variety	Principal Cultivations and Dates	Sowing Dates	Cutting or Raising Dates	Carting Dates	Manuring per Acre	Yield per Acre
Stackyard Field Series A	Tares and Mustard	—	Dec. 12-13—Tractor plough; Mar. 8 and 22—Tractor cultivate and harrow; Mar. 26—Cambridge roll; Mar. 28—Manure, sow tares, harrow and roll; Apl. 29—Sow mustard and harrow, and harrow tares; May 2 and 8—Harrow tares; July 17—Both crops a failure, so cut over; July 31, Aug. 6 and 8, Tractor cultivate; Sept. 9-10—Tractor plough	Tares—Mar. 28 Mustard—Apl. 29	Ploughed in	—	3 cwt. superphosphate 1 cwt. sulphate of potash	—
Stackyard Field Series C	Barley	Plumage Archer	Mar. 2-4—Tractor plough after feeding sheep; Mar. 5—Tractor cross-cultivate and harrow; Mar. 7—Sow barley and harrow; Mar. 8—Cambridge roll; Mar. 19—Sow Alsike Clover and harrow; Mar. 20—Flat roll	Barley—Mar. 7 Clover—Mar. 19	Aug. 7	Aug. 20	Manured by feeding off roots with cake or corn	34 bush. (average)
Stackyard Field Series D	Clover	Alsike	May 10—Mow over for weeds; July 6—Cut Clover	May 1 and Sept. 6, 1934	July 6	July 15	—	14 cwt. hay (average)
Lansome Piece (Green Manuring)	Wheat	Red Standard	Oct. 16-19—Plough in 2nd crop of Mustard and Tares; Oct. 26 Double roll; Nov. 2—Sow wheat and harrow; Mar. 18, Apl. 23, May 14—Harrow	Nov. 2, 1934	July 26	Aug. 13	Green manured with previous Mustard and Tares crop	12 bush. (average)

II. Grassland. Broad Mead, Paddocks 1 and 4, and the N.E. side of Great Hill Field were grazed and then laid in for hay, which was cut about July 18th. The remainder of Broad Mead and of Great Hill Field, as well as Roadpiece, Great Hill Bottom, Long Mead, Mill Dam Close, and Warren Field were grazed and cut over.

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, ROTHAMSTED, 1935

(The cultivations and manurings of the replicated experiments are given in the appropriate yield tables)

Field	Crop	Variety	Principal Cultivations and Dates	Manuring per acre	Sowing Dates	Cutting Dates	Carting Dates	Yield per acre
Great Knott	Beans	Winter	T. Cultivate barley stubble both ways, Sept. 1, 5 and 12; harrow, Oct. 1; harrow and plough in seed at 3½ bushels per acre, Oct. 2 and 3. Own seed from 1934 crop; Beans harrowed twice across the rows, March 19 and 20.	None	Oct. 2 and 3	Aug. 2	Sept. 3	10 cwt.
Great Harpenden	Wheat	Victor	Ewes run on bean stubble; T. Wilder harrowed; Sept. 8-10 and T. thistlebar. H. harrowed and own seed drilled Oct. 26 at 3 bushels per acre with precision drill; harrowed in Oct. 27 Feb. 11, Little Joss sown and harrowed in Feb. 12. May 17, Linseed sown at 1¾ bushels per acre where spring wheat failed.	March 20, 21 1 cwt. sulphate of ammonia per acre	Oct. 26	Aug. 6	Aug. 28 Sept. 9 Cart Linseed	Linseed 7 cwt.
Fosters	Barley	Plumage Archer	Started H. plough N. side after sheep on Kale, Feb. 13 -Mar. 5. Brussels roots ploughed out with beet lifter and ploughing continued. March 7 and 13 Spring-tine harrow. Mar. 15 and 16, harrow and drill barley on N half, harrowed and ring rolled, March 16. March 28-30, T and H. plough S. side. H. harrowed and drilled; ring rolled April 2; harrowed April 4.	None	March 14 and 30	Aug. 10	Aug. 22	20 cwt.
Little Hoos	—	—	Annual Expts.					
Pennell's Piece	Wheat	Danish Steel Monarch	Aug. 27-28, H. ploughed 5 inches deep. Oct. 16, T. cultivated; Oct. 24, H. harrowed; Nov. 2, 1934, drilled and harrowed in.	April 2, 1 cwt. sulphate of ammonia	Nov. 2, 1934	Aug. 8	Sept. 1	17 cwt.

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, ROTHAMSTED, 1935 (*Continued*)

Field	Crop.	Variety	Principal Cultivations and Dates	Manuring per acre	Sowing Dates	Cutting Dates	Carting Dates	Yield per acre
Pastures	Kale	Marrow Stem	Aug. 28, T. cultivate both ways. Sept. 7, T. Wilder harrow across. Sept. 10, weeds harrowed and burnt. Sept. 17-22, F.Y.M. carted at 25 tons per acre. March 22-25, T. plough N. side and T. cultivate, March 26. T. cultivate, April 24. T. roll and harrow, April 29. April 30, H. ring roll. Kale drilled at 4 lbs. per acre. May 1, H. harrow and roll. Horse-hoed throughout season.	F.Y.M. 25 tons per acre, Sept. 17. 2 cwt. sulphate of ammonia, May 2	May 2	—	—	15 tons
Long Hoos, I, II, and III.	Spring Oats	Marvellous	T. and H. plough, Feb. 2, 5, 7. Feb. 19, cross cultivated. Spring-tine harrowed, Feb. 21 and March 6. Oats drilled at 4 bushels per acre, March 7, after harrow;ng, with harrow and ring roll to follow. April 23, H. ring rolled. May 2, seeds mixture sown. Hand hoeing, June 11	1½ cwt. sulphate of Ammonia, Mar. 18	March 7 and 12	July 31	Aug. 19	25 cwt.
Harwood's Piece	Kale	Thousand head	T. thistlebar Oct. 13, and T. cultivate both ways, Oct. 27 and 29. T. plough and pick docks, March 18-21. T. cultivate, April 25. T. roll and harrow, April 30. May 2. T. harrow and roll for seed bed. Kale drilled and H. rolled and harrowed in, May 3. H. hoeing, July 8, 9, 10. Pull docks and charlock, July 31. Started folding tegs, Oct. E. strip 1¼ acres was sold for human consumption	Adco powder at 3 cwt. May 20, also June 3. 2 cwt. sulphate of ammonia July 26	May 3 at 5 lbs. per acre	Sheep folded	—	12 tons

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, ROTHAMSTED, 1935 (*Continued*)

Field	Crop	Variety	Principal Cultivations and Dates	Manuring per acre	Sowing Dates	Cutting Dates	Carting Dates	Yield per acre
Grassland								
Great Field I.	Grazed	Old Pasture	T. chain harrowed and rolled, March 8	None	—	—	—	—
II.	Hay after grazing	Ditto	T. chain harrowed and rolled, March 8	Ditto	—	June 29	July 4	38 cwt. (I. and II.)
III.	Ditto	Ditto	T. chain harrowed and rolled, March 8	Ditto	—	Ditto	Ditto	
Little Knott, I. and II.	Hay after late grazing	See Report 1931	Heavy grazing by cattle, sheep and pigs	None	See report 1931	July 16	July 20	15 cwt. approx.
Great Knott I.	Hay	Ditto	T. chain harrowed, April 15. Stones picked off and I. put up for hay	1 cwt. sulphate of ammonia in April	Ditto	July 5	July 8	32 cwt.
II.	Hay after grazing	Ditto	Ditto	None	Ditto	Ditto	Ditto	Ditto
West Barnfield I and II.	Ditto	Ditto	H. harrowed Feb. 18, T. harrowed, March 4th	None	Ditto	July 9	July 12	$28\frac{1}{2}$ cwt.
Foster's Corner	Grazed	Ditto	Topped July	None	Ditto	—	—	—
Great Harpenden	Grazed	Ditto	T. harrowed with chain harrow, March 7	None	Ditto	July 15	—	Small
Stackyard	Hay	Ditto	Chain harrowed April 5. T. rolled April 22	1 cwt. sulphate of ammonia, April 15	Ditto	June 22	June 28	30 cwt.
New Zealand	Hay after grazing	Ditto	Nettles and hedgerows scythed	None	Ditto	July 13	July 18	22 cwt.
Sawyers, I. / II. / III.	Grazed / Hay / Grazed	Ditto	Chain harrowed, March 5, 6, 7, and II. put up for hay, April 26. Stones picked of II. III. topped and hay added to II.	None	Ditto	June 25	June 29	24 cwt.
Hill Harpenden	Grazed	Old Pasture	T. chain harrowed, April 15, and rolled. Topped in summer.	None	—	June 20	—	—
Delharding	Ditto	Ditto	Ditto	Ditto	—	Ditto	—	—
High Field	Grazed	Ditto	Double tine and chain harrow, April 5 to 9. Topped and raked, July 25 and Aug. 3.	None	—	—	—	—

DETAILED RESULTS OF THE EXPERIMENTS 1935

Notes on the Construction and Use of the Summary Tables.

The presentation of the results of simple experiments is an easy matter, it being usually sufficient to give the mean yields of the individual treatments with an associated standard error by which differences may be compared; a difference of three times the standard error of a treatment mean may be regarded as significant. In the case of complex or *factorial* experiments, however, where there are all combinations of several sets of treatments, or other factors, the mere presentation of the mean yields of the sets of plots receiving all the different combinations of treatments does not give an adequate or easily comprehended survey of the results.

In order to illustrate the points involved we will first consider the simple type of factorial design in which there are all combinations of two standard fertilisers, nitrogen and phosphate, each at one level in addition to no application. This is called a 2×2 design, and involves the four treatment combinations

$$(1),\ n,\ p,\ np,$$

the symbol (1) being used to denote no treatment. Each treatment combination will be replicated several times, using a randomised block or Latin square layout. In what follows the symbols are taken to represent the mean yields of each particular combination of treatments.

There are two responses to n, one in the absence of p, namely $(n-(1))$, and one in the presence of p, namely $(np-p)$. These two responses may differ, but frequently the difference is small—too small to be distinguished from experimental error—and in such cases it is often sufficient in considering the results of the experiment to take the average response to n when p is both present and absent. This average response, or *main effect*, is clearly

$$N=\tfrac{1}{2}\,[(np-p)+(n-(1))]=\tfrac{1}{2}[np-p+n-(1)]=\tfrac{1}{2}[n-(1)]\,[p+(1)].$$

The advantage of the use of (1) instead of 0 to denote no treatment is that it makes possible the above very simple formal algebraic statement.

The differential response to n in the presence and absence of p is the difference between the response to n when p is present, and the response when p is absent. In the tables of the reports for 1934 and all previous years this difference,

$$(np-p)-(n-(1))=np-p-n+(1),$$

has been called the *interaction* between n and p. In reports for the year 1935 onwards (i.e. beginning with the present report), the interaction has been redefined as *one half* the above difference, i.e. in symbols by

$$N.P=\tfrac{1}{2}[(np-p)-(n-(1))]=\tfrac{1}{2}[np-p-n+(1)]=\tfrac{1}{2}[n-(1)][p-(1)].$$

Note that the differential response to n in the presence and absence of p is the same as the differential response to p in the presence and absence of n, i.e., there is only one interaction between n and p.

The introduction of the factor $\tfrac{1}{2}$ has the following advantages. First the standard errors of the main effects and all interactions of any $2\times2\times2\times\ldots$ design are then equal, and secondly the response to any treatment in association with any combination of the other treatments is expressible as the sum or difference of the various main effects and interactions, without any numerical factors. Thus in a 2×2 design the following relations hold:

Response to	Expression in Terms of Treatment Combinations	Expression in Terms of Main Effects and Interactions
n (mean over all p)	$\frac{1}{2}[np+n—p—(1)]$	N
n (p absent)	$n—(1)$	$N—N.P$
n (p present)	$np—p$	$N+N.P$
n and p together	$np—(1)$	$N+P$

Similar expressions will hold for any other 2×2 design.

It should be particularly noted that the interaction does not enter into the expression for the response to n and p applied together.

Since the main effects and interactions are statistically independent the standard error of the sum or difference of two of them is $\sqrt{2}$ times the standard error of each.

Example. Peas, Biggleswade, 1933. The mean yields (ignoring slag, which produced no apparent effect) were (in cwt. per acre):

	(1)	n	k	nk	
cwt. per acre:	33.0	38.0	32.0	34.1	± 1.00

The main effects and interactions are therefore:

$$\left.\begin{array}{r} N\ \ 3.6 \\ K—2.4 \\ N.K—1.4 \end{array}\right\} \pm 1.00$$

There is a significant response to nitrogen and a significant depression with potash, the interaction not being significant. If the interaction, though not significant, is not assumed non-existent, the estimate of the response to n alone is

$$N—N.K=n—(1)=+5.0 \quad \pm 1.41.$$

The estimate of the response to the two fertilisers together is

$$N+K=nk—(1)=+1.2 \quad \pm 1.41.$$

The $2\times 2\times 2$ arrangement is similar. The eight treatment combinations are

$$(1),\ n,\ p,\ k,\ np,\ nk,\ pk,\ npk.$$

The main effect of n is the average of the four responses, and is therefore

$$N=\tfrac{1}{4}[(npk—pk)+(np—p)+(nk—k)+(n—(1))]=\tfrac{1}{4}[n—(1)]\,[p+(1)]\,[k+(1)].$$

The *first order* interaction between N and P is defined as the average of the interactions between N and P in the presence and absence of K, and is therefore

$$N.P=\tfrac{1}{2}[\tfrac{1}{2}(npk—nk—pk+k)+\tfrac{1}{2}(np—n—p+(1))]=\tfrac{1}{4}[n—(1)][p—(1)][k+(1)],$$

and the *second order* interaction is defined as *one half* the difference of the above two interactions, and is therefore

$$N.P.K=\tfrac{1}{2}[\tfrac{1}{2}(npk—nk—pk+k)—\tfrac{1}{2}(np—n—p+(1))]=\tfrac{1}{4}[n—(1)]\,[p—(1)]\,[k—(1)]$$

Just as there is only one interaction between two treatments, so there are three first order interactions between three treatments, one between each of the pairs of the treatments, but only one second order interaction between the three treatments.

The following expressions for various typical responses may be noted:

Response to:	Expression in Terms of Treatment Combinations	Expression in Terms of Main Effects and Interactions
n (p absent, mean of k and no k)	$\frac{1}{2}[nk+n—k—(1)]$	$N—N.P$
n (p and k absent)	$n—(1)$	$N—N.P—N.K$ $+N.P.K$
n and p (mean of k and no k)	$\frac{1}{2}[npk+np—k—(1)]$	$N+P$
n and p (k absent)	$np—(1)$	$N+P—N.K—P.K$
n, p and k (complete fertiliser)	$npk—(1)$	$N+P+K+N.P.K$

If the second order interaction is ignored the response to all three factors in conjunction is equal to the sum of the main effects of the three factors.

When three levels of a fertiliser are included the situation is somewhat more complicated. If the yields at no, single and double dressing are n_0, n_1, n_2 the response to the double dressing, which may be defined as the *linear response*, is measured by

$$N_1 = n_2 - n_0,$$

and the excess of the response to the second dressing over the response to the first, which may be defined as the *curvature* of the response curve, is measured by

$$N_2 = (n_2 - n_1) - (n_1 - n_0) = n_2 - 2n_1 + n_0.$$

With the ordinary type of fertiliser response curve the curvature will in general be negative.

With this convention the response to the single dressing is given by

$$n_1 - n_0 = \tfrac{1}{2}(N_1 - N_2),$$

and the additional response to the double dressing is given by

$$n_2 - n_1 = \tfrac{1}{2}(N_1 + N_2.)$$

With two fertilisers each at three levels the linear response and curvature to each fertiliser will be the mean of such responses over all three levels of the other fertiliser. The *interaction of the linear responses* will be defined as

$$N_1.P_1 = \tfrac{1}{2}(n_2p_2 - n_2p_0 - n_0p_2 + n_0p_0) = \tfrac{1}{2}(n_2 - n_0)\ (p_2 - p_0).$$

(The factor $\frac{1}{2}$ is omitted in the tables given in the 1934 report.) The other three components of interaction may be defined similarly, but in a first study of the results of 3×3 fertiliser experiments it is usually sufficient to confine attention to the above component of interaction. In $3 \times 3 \times 3$ experiments the *second order interaction of linear responses*, namely

$$N_1.P_1.K_1 = \tfrac{1}{4}(n_2p_2k_2 - n_2p_2k_0 - n_2p_0k_2 - n_0p_2k_2 + n_0p_0k_2 + n_0p_2k_0 + n_2p_0k_0 - n_0p_0k_0) = \tfrac{1}{4}(n_2 - n_0)\ (p_2 - p_0)\ (k_2 - k_0),$$

may be of interest.

The summaries of this report are so arranged that as far as possible the main effects and first order interactions are available without the necessity of taking out any means. The first order interactions are often given in the form of response to one treatment in the presence of, and in the absence of the other, under the heading of "differential responses." The standard errors (prefaced by the sign $\pm$) applicable to all comparisons which are likely to be of interest are also shown. They are deduced from the standard errors per plot, which are given in the details of the experiment.

The rough rule for use with standard errors is that a quantity is significant if it is greater than twice its standard error, and the difference between two quantities having the same standard error is significant if it is three times that standard error. Thus the mean response to sulphate of ammonia in the 1933 Brussels Sprouts experiment at Woburn is given as 9.01 cwt. $\pm$1.89 cwt., which is therefore significant, since the response is almost 5 times its standard error. The responses in the absence and presence of poultry manure are 12.38 cwt. and 5.64 cwt., each with a standard error of $\pm$2.67, and the differential response (or interaction) which is the difference of these, though suggestive, is not significant, being only about two and a half times the standard error of each of them. The response to sulphate of ammonia in the presence of poultry manure, 5.64, is significant, being more than twice its standard error. The same interaction can be looked at from the point of view of response to poultry manure in the absence and presence of sulphate of ammonia. These responses are 8.18 and 1.44 cwt., again with a standard error of $\pm$2.67, giving a mean response of

4.81 cwt. with a standard error of ± 1.89. The mean response and the response in the absence of sulphate of ammonia are therefore significant, but the response in the presence of sulphate of ammonia is small and not significant. We have here a case of common occurrence where one of two quantities is significant and the other is not, but where the two quantities do not differ significantly from one another.

Standard errors, besides their use for testing the significance of comparisons from one particular experiment, are of importance when the results of a number of experiments are combined, since they serve as a measure of the reliability of each experiment, and also give the information necessary for telling whether the variation from experiment to experiment in the effect under survey is a real one or whether it can be attributed to experimental errors.

The second and higher order interactions are likely to be of even less importance than the first order interactions, and this fact is made use of in confounding, which is a modification of the randomised block method, introduced in order to keep the number of plots per block small while allowing a large number of different treatments. In confounded experiments certain comparisons representing high order interactions are confounded (i.e. mixed up) with differences between blocks. Thus in the $2 \times 2 \times 2$ arrangement given above, the plots receiving the treatments *npk*, *n*, *p* and *k* might be put in one set of sub-blocks of 4 plots, and the plots receiving treatments *np*, *nk*, *pk* and (1) in another set of sub-blocks of 4 plots. The second order interaction would then be completely confounded. On irregular land a considerable increase of precision may result from keeping the blocks small. There are many examples of confounding of varying complexity in the experiments of this report. There is not space to discuss all the implications of confounding here, but it will be seen that in general the results of interest, namely the main effects and first order interactions, are unaffected by confounding, and tables involving these interactions only can be used without regard to the confounding. In certain cases, e.g., $3 \times 2 \times 2$ and $3 \times 3 \times 2$ experiments, where some of the first order interactions are unavoidably slightly confounded, these interactions have slightly higher standard errors than the others ; this is indicated in the tables themselves, the correct standard errors being given.

The higher order interactions are not only unimportant, but it can often be confidently predicted that they are likely to be very small in magnitude compared with the experimental errors. They can therefore be used to provide an estimate of experimental error instead of the usual estimate provided by replication. This makes possible complex experiments in which each combination of treatments occurs once only, thus enabling greater complexity to be attained with a reasonable number of plots. The 1933 potato experiment at Wisbech is an example of this type of layout.

K

CHEMICAL ANALYSES OF MANURES USED IN REPLICATED EXPERIMENTS, 1935

Manures.	% N	% P_2O_5	% K_2O
Sulphate of Ammonia	20.9	—	—
Nitrate of Soda	16.0	—	—
Nitrochalk	15.2	—	—
Cyanamide	19.9	—	—
Poultry Manure (Dried)	3.77	3.34	1.66
Rape Dust	5.20	2.47	1.44
Malt Culms	3.93	1.46	1.97
Soot	4.29, 4.46	—	—
Fish Guano	8.41	5.63	1.48
Dung (1)	0.66	0.25	0.92
Dung (2)	0.42	0.19	0.62
Dung (3)	0.54	0.19	0.62
Dung (3)	0.52	0.19	0.62
Superphosphate	16.6—16.8 (Total) 16.2—(Water Sol.)	% P_2O_5	
Sulphate of Potash	48.9	% K_2O	
Muriate of Potash	52.0	% K_2O	

(1) Used in Beans Experiment, Rothamsted 35 RE. 1-32.

(2) Used in Sugar Beet Experiment, Rothamsted 35 RS. 1-54, 35 RS. 55-102.

(3) Used in Potato Experiment, Rothamsted 35 RP. 1-72.

Three Course Rotation

Manures.	% Organic Matter.	% N	% P_2O_5	% K_2O
Chaffed Straw	86.0	0.48	0.08	1.04
Adco	16.0	0.33	0.37	0.25
Superphosphate	—	—	16.6 (1) (2)	—
Sulphate of Ammonia	—	21.0(1) 20.9(2)	—	—
Muriate of Potash	—	—	—	51.6(1) 52.0(2)
Nitrate of Soda	—	16.0	—	—

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

Four Course Rotation

Manures.	% Organic Matter.	% N	% P_2O_5	% K_2O
Chaffed Straw	86.0	0.48	0.08	1.04
Dung	22.2	0.89	0.30	0.89
Adco	16.0	0.33	0.37	0.25
Superphosphate	—	—	16.6	—
Mineral Phosphate (90% through 120 mesh)	—	—	26.7(1) 25.7(2)	—
Muriate of Potash	—	—	—	51.6
Sulphate of Ammonia	—	21.0	—	—

(1) Applied to the ryegrass. (2) Applied to barley, wheat, potatoes.

Six Course Rotation

Sulphate of Ammonia ..	.. 20.9% N
Superphosphate ..	.. 16.6(1) (2) % P_2O_5
Muriate of Potash	.. 51.6(1), 52.0(2)% K_2O
(1) Applied in Autumn.	(2) Applied in Spring.

AVERAGE WHEAT YIELDS OF VARIOUS COUNTRIES

Country.	Mean yield per acre, 1925-34 cwt.	Country.	Mean yield per acre, 1925-34 cwt.
Great Britain	17.9	Denmark	22.8
England and Wales ..	17.7	Argentine	7.0
Hertfordshire	16.7	Australia	6.1
France	12.0	Canada	8.6
Germany	16.4	United States..	7.4
Belgium	20.8	U.S.S.R. (Europe and Asia)	6.0*

Note—Figures for Great Britain, England and Hertfordshire are taken from the Ministry of Agriculture's "Agricultural Statistics," Vol. 69. Other figures from "International Year Book of Agricultural Statistics," 1928-35.

* 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)	0.453 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	1.118 Kilogrammes per Hectare
1 cwt. per acre	1.256 dz. per Hectare
1 ton per acre	25.12 dz. per Hectare
1 dz. per Hectare	0.796 cwt. per acre
1 kg. per Hectare	0.892 lb. per acre

In America the Winchester bushel is used = 35.236 litres. 1 English bushel = 1.032 American bushels. 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, 1935

	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 gr'd.	Solar Max.	Grass Min.
1935—	Inches.	No.	Inches.	Inches.	Inches.	Hours.	°F	°F	°F	°F	°F
Jan. . .	1.072	15	0.692	0.801	0.771	46.7	42.7	35.5	40.4	68.7	31.7
Feb. . .	2.917	17	1.965	2.079	2.048	53.0	46.3	36.5	40.2	82.8	32.5
Mar. . .	0.634	9	0.086	0.179	0.169	134.3	49.4	36.1	41.3	96.7	31.6
April	3.954	23	1.826	1.964	1.826	126.7	51.9	39.0	45.5	99.2	34.6
May	1.907	9	0.163	0.206	0.182	193.8	57.7	41.2	50.3	100.6	37.8
June	3.004	19	0.853	0.989	0.920	195.0	66.2	51.1	58.1	109.1	46.5
July	0.961	5	0.000	0.005	0.007	280.1	72.8	53.4	64.8	137.0	48.2
Aug. . .	1.635	9	0.000	0.000	0.000	203.9	71.8	52.4	63.7	131.2	46.1
Sept.	4.467	18	2.093	2.101	1.994	149.9	63.5	49.3	57.5	119.8	44.4
Oct. . .	2.986	18	1.674	1.689	1.638	112.1	54.5	42.3	49.9	—*	37.3
Nov. . .	5.384	26	4.725	4.880	4.759	61.9	48.5	38.0	44.4	—*	33.5
Dec.	3.195	21	2.771	2.914	2.960	47.5	40.9	32.5	37.5	—*	28.3
Total or Mean	32.116	189	16.848	17.807	17.274	1604.9	55.5	42.3	49.5		37.7

*These readings have been discontinued.

RAIN AND DRAINAGE
MONTHLY MEAN FOR 65 HARVEST YEARS 1870-1—1934-5

	Rain-fall.	Drainage.			Drainage % of Rainfall.			Evaporation.		
		20-in. Gauge.	40-in. Gauge.	60-in. Gauge.	20-in. Gauge.	40-in. Gauge.	60-in. Gauge.	20-in. Gauge.	40-in. Gauge.	60-in. Gauge.
	Ins.	Ins.	Ins.	Ins.	%	%	%	Ins.	Ins.	Ins.
Sept. . .	2.378	0.804	0.781	0.721	33.8	32.8	30.3	1.574	1.597	1.657
Oct. . .	3.085	1.738	1.716	1.589	56.3	55.6	51.5	1.347	1.369	1.496
Nov. . .	2.834	2.159	2.212	2.087	76.2	78.1	73.6	0.675	0.622	0.747
Dec. . .	2.814	2.395	2.493	2.380	85.1	88.6	84.6	0.419	0.321	0.434
Jan. . .	2.375	1.944	2.136	2.039	81.9	89.9	85.9	0.431	0.239	0.336
Feb. . .	1.995	1.473	1.586	1.514	73.8	79.5	75.9	0.522	0.409	0.481
Mar. . .	1.968	1.051	1.177	1.114	53.4	59.8	56.6	0.917	0.791	0.854
April . .	2.067	0.678	0.757	0.720	32.8	36.6	34.8	1.389	1.310	1.347
May . .	2.074	0.496	0.562	0.530	23.9	27.1	25.5	1.578	1.512	1.544
June . .	2.178	0.512	0.542	0.521	23.5	24.9	23.9	1.666	1.636	1.657
July . .	2.664	0.693	0.721	0.674	26.0	27.1	25.3	1.971	1.943	1.990
Aug. . .	2.596	0.683	0.697	0.656	26.3	26.8	25.3	1.913	1.899	1.940
Year . .	29.028	14.626	15.380	14.545	50.4	53.0	50.1	14.402	13.648	14.483

CROPS GROWN IN ROTATION, AGDELL FIELD

PRODUCE PER ACRE

Year	Crop		O Unmanured since 1848. 5 Fallow	O Unmanured since 1848. 6 Clover or Beans	M Mineral Manure‡ No Nitrogen 3 Fallow	M Mineral Manure‡ No Nitrogen 4 Clover or Beans	C Complete Mineral and Nitrogenous Manure 1 Fallow	C Complete Mineral and Nitrogenous Manure 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 (22nd), 1932-35							
1932	Roots (Turnips) ..	cwt.	20.2	5.4	86.0	118.0	120.0	98.6
1933	Barley—							
	Dressed Grain	bush.	6.0	2.2	9.5	13.9	3.7	5.4
	Total Grain ..	cwt.	3.3	1.3	5.2	7.4	2.0	2.9
	Weight per bushel	lb.	54.8	50.2	55.2	55.0	52.9	53.0
	Total Straw ..	cwt.†	6.3	4.8	7.4	11.4	9.1	14.0
1934	Beans—							
	Dressed Grain	bush.	—	9.2	—	24.6	—	13.1
	Total Grain ..	cwt.	—	5.6	—	15.2	—	8.1
	Weight per bushel	lb.	—	67.8	—	69.4	—	69.6
	Total Straw ..	cwt.	—	10.5	—	28.3	—	16.5
1935	Wheat—							
	Dressed Grain	bush.	14.6	13.7	19.5	16.0	10.5	12.0
	Total Grain ..	cwt.	9.3	8.7	12.6	10.1	6.6	7.6
	Weight per bushel	lb.	62.1	63.2	62.9	63.8	62.4	63.5
	Total Straw ..	cwt.†	22.4	20.2	33.9	28.5	28.3	23.5

* 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. Superphosphate (35%); 500 lb. Sulphate of Potash; 100 lb. Sulphate of Soda; 200 lb. Sulphate of Magnesia, all per acre. Nitrogenous Manure; 206 lb. Sulphate of Ammonia and 2,000 lb. Rape Dust per acre. Manures applied once every four years, prior to sowing of Swedes.
‡‡ Based on 9 courses.
§ Based on 13 courses.

CULTIVATIONS, ETC.—Ploughed: August 30-September 7. Cultivated: October 6 and 13. Harrowed: October 25. Rolled: May 4. Seed sown: October 25. Variety: Red Standard. Harvested: August 1.

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 :

A	W	B
1		1
2		2
3		3
4		4

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.

PRODUCE PER ACRE, 1935

	B1	B2	B3	Mean	Average, 79 years, 1856-1934
Dressed Grain—bushels	9.8	5.7	15.6	10.4	14.4
Total grain—cwt.	6.3	3.7	9.7	6.6	8.2
Weight per bushel—lb.	62.3	62.0	63.5	62.6	58.8
Total straw—cwt.	12.0	8.3	19.8	13.4	12.8

CULTIVATIONS, ETC.—Cropped sections. Ploughed : August 23. Cultivated : August 23. Harrowed : October 20, March 21. Rolled : March 26. Seed sown : October 20. Variety : Red Standard. Harvested : August 13. Fallowed section. Ploughed : August 23, May 28. Cultivated: August 23, May 11, July 3.

MANGOLDS—BARNFIELD, 1935.

No crop in 1935. See p. 84.

HAY—THE PARK GRASS PLOTS, 1935

Plot.	Manuring (amounts stated are per acre).		Yield of Hay per acre.			Dry Matter per acre.		
			1st Crop	2nd* Crop	Total	1st Crop	2nd Crop	Total
			cwt.	cwt.	cwt.	cwt.	cwt.	cwt.
1	Single dressing (206 lb.) Sulphate of Ammonia (=43 lb.N.), (with Dung also 8 years, 1856-63)	not limed	14.8	3.6	18.4	11.2	2.9	14.1
		limed ..	19.3	1.3	20.6	16.1	1.1	17.2
2	Unmanured (after Dung 8 years, 1856-63)	not limed	15.4	2.7	18.1	11.2	2.2	13.4
		limed ..	15.5	1.8	17.3	11.2	1.4	12.6
3	Unmanured	not limed	13.2	2.0	15.2	9.5	1.6	11.1
		limed ..	15.4	1.1	16.5	11.4	0.8	12.2
4–1	Superphosphate of lime (3½ cwt.)	not limed	14.7	2.2	16.9	10.8	1.8	12.6
		limed ..	15.0	1.5	16.5	10.5	1.2	11.7
4–2	Superphosphate of lime (3½ cwt.), and double dressing (412 lb.) Sulphate of Ammonia (=86 lb. N.)	not limed	31.8	1.7	33.5	25.9	1.4	27.3
		limed ..	33.5	3.0	36.5	27.1	2.4	29.5
5–1	(N. half) Unmanured following double dressing Ammonia salts (=86 lb. N.) 1856-97	not limed	10.9	2.5	13.4	8.4	2.0	10.4
5–2	(S. half) Superphosphate (3½ cwt.) Sulphate of Potash (500 lb.) following double dressing Amm. salts (=86 lb. N.) 1856-97	not limed	21.9	5.5	27.4	17.0	4.4	21.4
6	Complete Mineral Manure as Plot 7; following double dressing Amm. salts (=86 lb. N.) 1856-68	not limed	28.1	7.0	35.1	23.8	5.6	29.4
7	Complete Mineral Manure: Super. (3½ cwt.); Sulphate of Potash (500lb.); Sulphate of Soda (100lb.); Sulphate Magnesia (100lb.)	not limed	31.8	6.2	38.0	25.0	5.0	30.0
		limed ..	39.8	6.3	46.1	32.9	5.0	37.9
8	Mineral Manure without Potash	not limed	19.1	3.4	22.5	14.4	2.7	17.1
		limed ..	15.2	3.2	18.4	11.5	2.6	14.1
9	Complete Mineral Manure and double dressing (412 lb.) Sulphate of Ammonia (=86 lb. N.)	not limed	52.9	3.1	56.0	41.4	2.5	43.9
		limed ..	49.7	3.9	53.6	40.1	3.1	43.2
10	Mineral Manure (without Potash) and double dressing Amm. salts (=86 lb. N.)	not limed	35.7	1.2	36.9	28.1	1.0	29.1
		limed ..	33.0	4.3	37.3	28.7	3.5	32.2
11–1	Complete Mineral Manure and treble dressing (618 lb.) Sulphate of Amm. (129 lb. N.)	not limed	35.8	15.0	50.8	29.9	12.0	41.9
		limed ..	50.9	8.6	59.5	40.4	6.8	47.2
11–2	As Plot 11–1 and Silicate of Soda	not limed	49.2	15.6	64.8	35.5	12.5	48.0
		limed ..	54.4	11.2	65.6	40.5	9.0	49.5
12	Unmanured	not limed	13.2	4.2	17.4	10.8	3.3	14.1
13	Dung (14 tons) in 1905, and every fourth year since (omitted 1917) Fish Guano (6 cwt.) in 1907 and every fourth year since	not limed	39.1	7.3	46.4	32.8	5.9	38.7
		limed ..	45.2	9.7	54.9	37.5	7.8	45.3
14	Complete Mineral Manure and double dressing (550 lb.) Nitrate of Soda (=86 lb. N.)	not limed	54.1	10.7	64.8	42.5	8.5	51.0
		LimedSun	52.2	5.2	57.4	42.5	4.2	46.7
		,, Shade	42.7	2.2	44.9	31.6	1.8	33.4
15	Complete Mineral Manure as Plot 7: following double dressing Nitrate of Soda (=86 lb. N., 1858-75)	not limed	25.6	4.5	30.1	21.0	3.6	24.6
		limed ..	27.3	2.0	29.3	22.8	1.6	24.4
16	Complete Mineral Manure and single dressing (275 lb.) Nitrate of Soda (=43 lb. N.)	not limed	38.3	4.6	42.9	32.2	3.7	35.9
		limed ..	34.2	3.3	37.5	28.0	2.6	30.6
17	Single dressing (275 lb.) Nitrate of Soda (43 lb. N.)	not limed	21.5	2.8	24.3	15.9	2.2	18.1
		limed ..	24.2	1.3	25.5	19.7	1.0	20.7
18	Mineral Manure (without Super.), and double dressing Sulphate of Amm. (=86 lb. N.), 1905 and since; following Minerals and Amm. salts supplying the constituents of 1 ton of hay, 1865-1904	not limed	21.4	4.9	26.3	16.9	3.9	20.8
		limed 6788 lb.	26.2	2.1	28.3	20.6	1.7	22.3
		limed (3951 lb.)	25.3	3.3	28.6	19.6	2.6	22.2
19	Farmyard Dung (14 tons) in 1905 and every fourth year since (omitted in 1917), following Nitrate of Soda (=43 lb. N.) and Minerals, 1872-1904	not limed	30.1	6.6	36.7	23.0	5.2	28.2
		limed (3150 lb.)	31.7	5.6	37.3	24.1	4.5	28.6
		limed 570 lb.)	27.4	4.1	31.5	21.9	3.3	25.2
20	Farmyard Dung (14 tons) in 1905 and every fourth year since (omitted in 1917); each intervening year Plot 20 receives Sulphate of Potash (100 lb.); Superphosphate (200 lb.) and 1½ cwt. Nitrate of Soda (=26 lb. N.); following Nitrate of Potash and Superphosphate, 1872-1904	not limed	42.0	6.0	48.0	33.9	4.8	38.7
		limed (2772 lb.)	41.0	4.2	45.2	32.7	3.3	36.0
		limed 570 lb.)	43.9	4.0	47.9	35.9	3.2	39.1

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, and at the rate of 2,500 lb. to the acre in the winter of 1920-1921 except where otherwise stated.

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

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

CULTIVATIONS, ETC.—Harrowed: February 18. Rolled: March 25. Manures applied: February 26-27, March 1 and 28-29, May 3. Cut: 1st crop, June 24-26; 2nd crop, September 23-26.

PARK GRASS PLOTS

BOTANICAL COMPOSITION PER CENT—1935 (1st Crop)

Plot	Manuring	Liming.	Gramineae.	Leguminosae.	Other Orders.	" Other Orders " consist largely of
3	Unmanured	Limed	53.88	10.87	35.25	—
		Unlimed	46.67	9.74	43.58	—
7	Complete Mineral Manure	Limed	58.72	31.51	9.77	*Heracleum sphondylium*
		Unlimed	47.57	37.58	14.85	*Centaurea nigra* / *Plantago lanceolata*
8	Mineral Manure (without potash)	Limed	62.83	8.68	28.49	*Plantago lanceolata* / *Centaurea nigra*
		Unlimed	55.58	11.32	33.10	*Plantago lanceolata*
9	Complete Mineral Manure and double Amm. Salts	Limed	96.28	0.12	3.60	*Heracleum sphondylium*
		Unlimed	100.00	—	—	—
10	Mineral Manure (without potash) and double Amm. Salts	Limed	99.31	—	0.69	—
		Unlimed	99.90	—	0.10	—
14	Complete Mineral Manure and double Nitrate of Soda	Limed (sun)	82.68	12.37	4.95	*Anthriscus sylvestris*
		Limed (shade)	94.46	4.29	1.25	—
		Unlimed	93.00	0.94	6.06	*Anthriscus sylvestris*
18	Mineral Manure (without Super) and double Sulphate Amm. 1905 and since.	L.6,788 lb.	79.44	0.42	20.14	*Taraxacum vulgare*
		L.3,951 lb.	83.36	0.08	16.56	
		Unlimed	99.64	—	0.36	*Rumex acetosa*
19	Farmyard Dung in 1905 and every fourth year since (omitted 1917)	L.3,150 lb.	88.59	4.87	6.54	*Achillea millefolium*
		L.570 lb.	82.96	9.44	7.60	—
		Unlimed	81.49	6.98	11.53	—
20	Farmyard Dung in 1905 and every fourth year since (omitted in 1917): each intervening year Sulphate of potash, Super., and Nitrate of Soda	L.2,772 lb.	80.46	10.67	8.87	—
		L.570 lb.	89.18	4.89	5.93	*Achillea millefolium*
		Unlimed	90.20	3.89	5.91	—

PLOT	7 U	7 L	8 U	8 L	9 U	9 L	10 U	10 L	14 U	14 L (sun)	14 L (shade)
Gramineae											
1. Agrostis vulgaris	8.33	0.74	8.76	1.72	0.04	1.16	10.25	0.97	0.04	—	0.48
3. Alopecurus pratensis	3.62	11.30	0.85	2.67	—	62.09	0.21	55.22	61.91	22.28	20.01
4. Anthoxanthum odoratum	1.94	0.80	3.04	0.40	0.09	2.85	21.13	1.86	—	—	0.12
5. Arrhenatherum avenaceum ..	0.22	6.34	7.47	13.72	—	15.06	1.36	1.66	25.78	38.08	10.96
6. Avena flavescens	0.38	3.44	1.60	5.35	—	—	—	—	0.08	0.16	1.49
7. ,, pubescens	2.48	8.66	5.77	15.23	—	0.06	—	—	0.04	0.76	11.08
8. Briza media	—	—	0.37	1.36	—	—	—	—	—	—	—
9. Bromus mollis	—	2.95	—	0.10	—	1.28	—	—	1.72	0.36	0.65
10. Cynosurus cristatus	—	—	—	0.10	—	—	—	—	—	—	—
11. Dactylis glomerata	6.05	11.24	2.62	5.25	—	3.61	0.05	0.04	1.96	4.47	2.20
12. Festuca ovina	20.14	4.91	17.62	8.57	—	1.74	2.41	33.33	0.16	9.54	43.24
14. Holcus lanatus	3.02	0.18	6.41	5.14	99.87	4.36	64.44	—	—	0.04	0.18
15. Lolium perenne	—	—	—	0.10	—	—	—	—	—	—	—
16. Poa pratensis	1.35	4.48	1.07	1.51	—	4.07	—	6.23	0.74	4.55	3.22
17. ,, trivialis	0.05	3.69	—	1.61	—	—	0.05	—	0.57	2.44	0.83
Leguminosae											
1. Lathyrus pratense	30.99	23.59	0.32	0.66	—	0.12	—	—	0.94	12.37	4.17
2. Lotus corniculatus	2.75	—	4.43	3.43	—	—	—	—	—	—	—
4. Trifolium pratense	3.13	1.78	6.52	4.59	—	—	—	—	—	—	—
5. ,, repens	0.70	6.14	0.05	—	—	—	—	—	—	—	0.12
Other Orders											
1 & 2. Ranunculus spp.	0.27	0.25	0.80	0.50	—	—	—	—	—	—	—
4. Cerastium vulgatum	0.05	—	0.27	0.76	—	—	—	—	—	—	—
5. Stellaria graminea	0.16	0.74	0.21	0.05	—	—	—	—	—	—	—
7. Agrimonia eupatoria	—	—	—	0.66	—	—	—	—	—	—	—
12. Spiraea ulmaria	0.11	—	0.05	—	—	—	—	—	—	—	—
13. Anthriscus sylvestris	—	—	—	—	—	—	—	—	4.91	3.95	0.65
14. Conopodium denudatum	0.22	0.06	0.05	—	—	—	—	—	—	—	—
15. Heracleum sphondylium	2.32	2.95	0.11	—	—	2.79	—	—	0.04	—	—
16. Pimpinella saxifraga	—	0.06	0.59	0.81	—	—	—	—	—	—	—
17. Galium verum	—	—	1.39	—	—	—	—	—	—	—	—
18. Scabiosa arvensis	—	0.12	2.13	5.75	—	—	—	—	—	—	—
19. Achillea millefolium..	1.84	0.55	3.63	0.81	—	—	—	—	—	—	0.18
20. Centaurea nigra	4.97	1.35	2.94	5.09	—	—	—	—	—	—	—
24. Leontodon hispidus	—	0.25	6.09	4.08	—	—	—	—	—	—	—
26. Taraxacum vulgare	0.05	0.98	0.11	0.30	—	0.64	0.05	0.20	0.25	0.20	0.18
29. Plantago lanceolata	3.40	1.29	12.97	7.82	—	—	—	—	—	—	—
30. Veronica chamœdrys	—	0.55	0.37	0.55	—	—	—	—	—	—	—
34. Rumex acetosa	0.60	0.61	0.75	1.11	—	0.17	0.05	0.49	0.86	0.80	0.24
35. Luzula campestris	0.86	—	0.64	0.20	—	—	—	—	—	—	—

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WHEAT—BROADBALK FIELD, 1935

Plot.	Manurial Treatment (amounts stated are per acre).	Dressed Grain, bushels per acre (in some cases estimated from half or quarter-bushel).					Total Grain, cwt. per acre					74-year Average 1852-1925 (prior to fallow). Total Grain, cwt.
		I	II	IV	V	Mean	I	II	IV	V	Mean	
2A	Farmyard Manure (14 tons)	14.3	25.5	27.7	23.6	22.8	10.1	15.9	16.6	14.7	14.3	16.3**
2B	Farmyard Manure (14 tons)	20.6	23.7	25.7	21.4	22.8	13.9	14.9	16.0	12.8	14.4	19.4
3	Unmanured since 1839	7.0	3.5	20.5	3.7	8.7	5.8	3.1	12.4	3.0	6.1	6.7
5	Complete Mineral Manure §§	4.4	5.3	23.1	5.6	9.6	4.7	4.7	14.3	4.5	7.0	7.8
6	As 5, and 206 lb. Sulphate of Ammonia ..	9.0	11.0	27.5	16.5	16.0	6.4	7.8	16.9	10.3	10.4	12.5
7	As 5, and 412 lb. Sulphate of Ammonia ..	16.3	25.2	25.7	18.9	21.5	11.1	16.1	16.0	12.0	13.8	17.6
8	As 5, and 618 lb. Sulphate of Ammonia ..	13.4	24.2	31.3	17.6	21.6	9.7	15.1	19.2	11.7	13.9	20.1
9	As 5, and 275 lb. Nitrate of Soda	13.1	17.6	23.3	18.9	18.2	8.8	11.4	14.7	12.3	11.8	13.9††
10	412 lb. Sulphate of Ammonia	13.9	18.8	17.6	23.9	18.6	9.4	12.2	11.0	14.5	11.8	10.9
11	As 10, and Superphosphate (3½ cwt.)	12.4	15.5	17.8	15.4	15.3	8.3	10.0	11.0	9.6	9.7	12.3
12	As 10, and Super (3½ cwt.) and Sulph. Soda (366 lb.)	16.0	17.7	19.8	16.6	17.5	10.6	11.3	12.3	11.0	11.3	15.7
13	As 10, and Super (3½ cwt.) and Sulph. Potash (200 lb.)	15.3	22.5	25.6	18.1	20.4	10.0	14.3	15.7	12.1	13.0	17.0
14	As 10, and Super. (3½ cwt.) and Sulph. Magnesia (280 lb.)	13.6	18.1	24.4	14.9	17.8	9.5	11.8	14.3	10.1	11.4	15.5
15	As 5, and 412 lb. Sulphate Amm. all applied in Autumn	10.2	18.0	30.4	18.9	19.4	7.4	11.3	18.3	11.8	12.2	16.1
16	As 5, and 550 lb. Nitrate of Soda	11.8	23.6	25.1	19.8	20.1	8.8	15.0	15.4	12.4	12.9	17.8††
17	Minerals alone as 5 or 412 lb. Sulphate of	M 5.4	8.3	31.1	9.6	13.6	4.1	6.0	18.9	5.7	8.7	M8.1*
18	Ammonia alone in alternate years	A8.2	19.0	22.0	17.9	16.8	6.4	12.4	13.5	11.1	10.8	A16.1
19	Rape Cake (1,889 lb.)	9.9	15.9	29.7	25.5	20.2	7.2	10.0	18.3	16.3	13.0	12.6‡
20	As 7, without Super	10.9	10.1	—	—	10.5	6.6	6.2	—	—	6.4	10.3§

FALLOWING ROTATION. After the fallows of 1925-6 to 1928-9 a regular cycle of fallowing was started in the season 1930-31. 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.

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WHEAT—BROADBALK FIELD, 1935

Plot.	Manurial Treatment (amounts stated are per acre).	Bushel Weight in lb. (in some cases estimated from half or quarter-bushel).					Total Straw†, cwt. per acre.					74-year Average 1852-1925 (prior to fallow). Total Straw, cwt.
		I	II	IV	V	Mean	I	II	IV	V	Mean	
2A	Farmyard Manure (14 tons)	61.4	64.0	61.8	63.0	62.6	58.0	54.3	71.4	63.8	61.9	32.1**
2B	Farmyard Manure (14 tons)	61.9	64.2	62.9	63.3	63.1	66.0	62.8	70.9	74.4	68.5	34.2
3	Unmanured since 1839	61.8	61.6	63.9	62.0	62.3	16.8	9.5	24.8	8.2	14.8	9.8
5	Complete Mineral Manure§§	56.4	60.4	64.1	62.4	60.8	26.0	16.0	31.2	14.2	21.8	11.5
6	As 5, and 206 lb. Sulphate of Ammonia	61.2	63.0	64.2	65.0	63.4	25.3	21.4	45.6	32.3	31.2	20.3
7	As 5, and 412 lb. Sulphate of Ammonia	62.2	64.7	63.5	64.6	63.8	55.5	32.5	61.4	55.3	51.2	32.1
8	As 5, and 618 lb. Sulphate of Ammonia	60.7	63.7	62.5	62.6	62.4	66.3	63.7	71.4	72.7	68.5	39.8
9	As 5, and 275 lb. Nitrate of Soda	62.5	63.8	64.0	64.7	63.8	35.6	32.0	52.4	40.0	40.0	24.6††
10	412 lb. Sulphate of Ammonia	62.7	63.9	63.6	64.5	63.7	33.0	30.8	35.3	40.2	34.8	17.8
11	As 10, and Superphosphate (3½ cwt.)	63.2	64.4	64.0	63.8	63.8	36.5	31.3	41.3	41.2	37.6	21.4
12	As 10, and Super. (3½ cwt.) and Sulph. Soda (366 lb.)	63.5	64.0	63.5	64.0	63.8	42.5	34.9	46.2	43.3	41.7	26.8
13	As 10, and Super. (3½ cwt.) and Sulph. Potash (200 lb.)	62.7	64.4	63.1	63.4	63.4	43.2	39.6	59.9	52.4	48.8	30.6
14	As 10, and Super. (3½ cwt.) and Sulph. Magnesia (280 lb.)	63.6	64.3	62.0	63.6	63.4	50.8	33.9	52.9	45.7	45.8	26.8
15	As 5, and 412 lb. Sulphate Amm. all applied in Autumn	60.4	61.7	63.9	64.1	62.5	33.8	26.9	47.6	29.7	34.5	28.2
16	As 5, and 550 lb. Nitrate of Soda	61.4	62.8	62.8	64.0	62.8	53.2	50.3	63.2	56.9	55.9	35.2††
17	Minerals alone as 5 or 412 lb. Sulphate of	M59.2	62.6	64.1	64.2	62.5	13.0	15.4	36.6	14.4	19.8	M12.3*
18	Ammonia alone in alternate years	A61.2	63.8	63.4	65.3	63.4	40.9	35.4	56.6	46.1	44.8	A28.1
19	Rape Cake (1,889 lb.)	60.4	62.0	63.9	63.6	62.5	31.7	24.7	60.3	37.9	38.6	22.0‡
20	As 7, without Super	50.0	54.0	—	—	52.0	37.4	23.3	—	—	30.4	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. Sulphate of Ammonia is applied as to one-third in Autumn and two-thirds in Spring except for Plot 15. Nitrate of Soda is all given in Spring, there being two applications at an interval of a month on Plot 16.

CULTIVATIONS, ETC.—Cropped sections: Ploughed: August 15-21, September 20-25. Harrowed: October 20-24. Seed sown: October 23-24. Variety: Red Standard. Manures applied: October 18-19, March 27-28, May 3. Harvested: August 6-8. Fallowed section: Ploughed: August 15-21, September 20-25, July 22, October 3-14. Harrowed: October 20-23. Cultivated: March 11, April 23, May 1 and 29, July 4.

BROADBALK : SAMPLING FOR ROOT-ROTS, 1935.

Each plot was divided into ten portions, two samples, each consisting of two half-metres of row length, being taken from each portion. Plants were classified as :

Vigorous : Ears over 1 in. long with good grain.

Weak : Ears less than 1 in. long with good grain.

Whiteheads : Plants dead, with very shrivelled or no grain.

Plants were also classified according to clean, slight or heavy blackening of the stem-bases and roots.

All plants with whiteheads had heavy blackening of the roots. The table shows a summary of the results.

Blackening (of the stem bases and roots) was due partly to *Ophiobolus graminis* and partly to *Cercosporella herpotrichoides*. It was not found possible always to separate these two by a naked eye classification ; so that no attempt was made to distinguish between them in recording.

Series	Plot No.	Treatment	Ear classification			Root classification		
			Percentage of plants			Percentage of plants		
			Vigorous	Weak	White heads	Clean	Slight	Heavy
IV 1st year after fallow (Fallow, 1934)	2	Dung	69.7	15.2	15.2	9.4	46.8	43.8
	3	Unmanured	69.5	18.5	12.0	34.9	36.3	28.8
	5	Complete minerals ..	64.7	21.0	14.3	19.3	39.4	41.3
	6	Minerals + sulph. amm.	79.4	11.5	9.1	11.3	39.0	49.7
V 2nd year after fallow (Fallow, 1933)	2	Dung	73.1	13.8	13.1	11.1	56.3	32.6
	3	Unmanured	54.1	23.5	22.4	26.4	60.6	23.0
	5	Complete minerals ..	61.4	17.6	21.0	13.0	65.8	21.2
	6	Minerals + sulph. amm..	73.8	9.2	17.0	17.2	52.5	30.3
II 3rd year after fallow (Fallow, 1932)	2	Dung	68.7	20.0	11.3	18.6	53.3	28.0
	3	Unmanured ..	33.4	32.2	34.4	22.7	47.4	29.9
	5	Complete minerals ..	36.7	24.7	38.6	23.4	45.1	31.5
	6	Minerals + sulph. amm.	44.6	23.8	31.6	21.4	47.1	31.4
Control Gt. Harpenden		Victor wheat—after beans	88.0	8.0	4.0	80.3	16.0	3.6

Note.—The figures for the root classification are taken from vigorous and weak plants only since all whiteheads showed heavy blackening of the roots.

In the unmanured and mineral fertiliser plots sampled the amount of whiteheads increased progressively the longer the time which elapsed from the last fallowing. For the first, second and third years after fallowing the average percentages of whiteheads for plots 3, 5 and 6 together were 11.8, 20.1 and 34.8 respectively. This is what would be expected, although the figures are probably higher this year than usual, owing to weather conditions having been favourable for cereal root-rots, for some reason not fully understood. The figures for the dunged plot were aberrant, being a little higher than the others for the first year after fallowing, and remaining at about the same level or possibly decreasing slightly instead of increasing in subsequent years as on the plots with no dung. This may be a real effect due to factors such as microbiological antagonism. There was also less disease in the plot with mineral fertilisers and ammonium sulphate than in the plot with minerals alone.

The figures for the root classification were not so consistent, but gave no indication that the percentage of plants with heavy blackening increased with the time since the last fallow, the percentage being highest the first year after fallowing on all but the unmanured plot. Apart from the anomalous behaviour of the unmanured plot in the first year after fallowing the percentages of heavy blackening were about the same on all plots.

No connection was found between the percentage of whiteheads or of heavy blackening and plant number.

BARLEY—HOOS FIELD, 1935

Plot	Manuring (amounts stated are per acre).	Dressed Grain bushels per acre‖ 1935	Dressed Grain bushels per acre‖ Average 1852-1928	Total Grain cwt. per Acre	Bushel weight in lb.	Total Straw cwt. per Acre † 1935	Total Straw cwt. per Acre † Average 1852-1928
1O	Unmanured	8.6	13.4	5.2	55.2	11.1	7.8
2O	Superphosphate only (3½ cwt.) ..	18.7	19.0	10.6	57.3	14.7	9.8
3O	Alkali Salts only (200 lb. Sulphate of Potash; 100 lb. Sulphate of Soda; 100 lb. Sulphate of Magnesia)	15.8	14.3	9.1	56.5	13.2	8.7
4O	Complete Minerals; as 3O with Superphosphate (3½ cwt.) ..	28.4	19.0	15.6	56.1	19.1	11.2
5O	Potash (200 lb.) and Superphosphate (3½ cwt.)	18.4	15.5	10.5	58.1	14.0	9.4
1A	Ammonium Salts only (206 lb. Sulphate of Ammonia)	16.3	23.7	10.2	53.6	19.8	13.7
2A	Superphosphate and Amm. Salts..	51.1	35.8	28.3	57.2	31.1	20.4
3A	Alkali Salts and Amm. Salts ..	39.8	25.8	21.7	55.2	31.0	16.0
4A	Complete Minerals and Amm. Salts	57.2	39.3	31.0	57.6	35.3	23.6
5A	Potash, Super. and Amm. Salts	48.3	33.8	26.8	57.4	33.8	21.7
1AA	Nitrate of Soda only (275 lb.) ..	21.5	24.3*	12.5	52.7	23.8	15.4*
2AA	Superphosphate and Nitrate of Soda	55.1	38.8*	30.4	57.5	36.2	23.1*
3AA	Alkali Salts and Nitrate of Soda ..	33.6	24.5*	24.2	55.3	28.3	16.6*
4AA	Complete Minerals and Nitrate of Soda	53.4	37.7*	30.5	57.7	37.1	23.6*
1AAS	As Plot 1AA and Silicate of Soda (400 lb.)	42.7	30.2*	23.6	55.9	31.5	18.2*
2AAS	As Plot 2AA and Silicate of Soda (400 lb.)	55.2	39.7*	30.6	58.0	35.2	23.9*
3AAS	As Plot 3AA and Silicate of Soda (400 lb.)	45.0	31.2*	24.7	56.5	36.0	19.9*
4AAS	As Plot 4AA and Silicate of Soda (400 lb.)	66.1	39.9*	35.6	57.5	35.2	25.4*
1C	Rape Cake only (1,000 lb.) ..	48.2	35.5	26.2	57.0	29.7	20.6
2C	Superphosphate and Rape Cake ..	57.6	38.1	31.8	57.8	34.3	22.0
3C	Alkali Salts and Rape Cake ..	48.7	33.7	27.6	57.5	30.5	20.4
4C	Complete Minerals and Rape Cake	58.3	37.5	31.4	57.6	34.5	22.6
7-1	Dung (14 tons) 1852-71; afterwards unmanured	37.6	22.5‡	20.0	56.5	23.7	13.5‡
7-2	Farmyard Manure (14 tons) ..	57.7	44.6	33.9	57.1	59.3	28.1
6-1	Unmanured since 1852	19.7	14.7	11.0	54.2	18.4	8.6
6-2	Ashes from Laboratory furnace 1852-1933; afterwards unmanured	23.6	15.7	12.7	55.5	16.9	9.3
1N	Nitrate of Soda only (275 lb.) ..	35.0	28.7§	23.0	55.6	27.7	17.8§
2N	Nitrate of Soda only (275 lb.) ..	50.7	31.7§§	28.3	56.8	34.3	20.0§§

‖ 1 cwt. = 2.15 bushels. 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: September 5, January 8-22. Harrowed: March 6, 8-9. Rolled: May 8. Manures applied: January 8-22, March 4,5. Seed sown: March 8-9. Variety: Plumage Archer. Harvested: August 14.

FOUR COURSE ROTATION EXPERIMENT, ROTHAMSTED

RESIDUAL VALUES OF HUMIC AND PHOSPHATIC FERTILISERS

For details, see 1932 Report, p. 127

MANURES APPLIED, SEASON 1934-5

Treatment	Organic Fertilisers (cwt. per acre)				Additional Artificial Fertilisers (cwt. per acre)		
	Organic Matter	N	K_2O	P_2O_5	N. as S. of A.	K_2O as Mur. Pot.	P_2O_5 as Super.
1 ..	50 (as F.Y.M.)†	1.800	1.851	0.611	None†	1.149	0.589
2 ..	50 (as Adco)	1.030	0.793	1.167	0.770	2.207	0.033
3 ..	120.37 (as straw)	0.670	1.457	0.012	1.130	1.543	1.188
4 ..	None				0.36	0.6	1.2
5 ..	None				0.36	0.6	1.2*

* As mineral phosphate.

† The F.Y.M. used had too high a ratio of N. to organic matter, and had to be slightly diluted with straw. The adjustment was made so that a quantity of the mixture containing 50 cwt. of organic matter, also contained 1.8 cwt. of N. No additional sulphate of ammonia was therefore required. The weights applied per acre were 199.6 cwt. F.Y.M. and 6.6 cwt. straw.

CULTIVATIONS, ETC.

	Barley	Seeds†	Potatoes	Wheat
Variety	Plumage Archer	Ryegrass	Ally	Yeoman
Date of Sowing ..	March 13	Sept. 12	April 12	Oct. 23
Manures applied—				
Dung and Adco	Dec. 12	Sept. 7	Dec. 17	Sept. 10
Artificials to Adco and Dung ..	Dec. 12	Sept. 7	Dec. 17	Sept. 10
Straw	Dec. 13-Jan. 7	Sept. 7-8	Jan. 8-10	Sept. 11
Artificials to straw ..	Dec. 12, Feb. 12, Mar. 7	Sept. 7, Dec. 20, Mar. 7	Dec. 17, Feb. 12, Mar. 7	Sept. 10, Dec. 20, Mar. 7
Treatments 4 and 5 ..	March 7	Sept. 12, Mar. 19	April 5	Oct. 20, Mar. 19
Date of harvesting	Aug. 12	June 22	Oct. 14	Aug. 13
Previous crop ..	Potatoes	Barley	Wheat	Seeds hay
Cultivations—				
Ploughing ..	Dec. 13—Jan. 7-8	Sept. 7-8	Jan. 8-10	July 18, Sept. 11-13
Harrowing ..	March 12, 14	Sept. 12, 13	Mar. 29, May 7, 16	Oct. 20, 23, Mar. 21
Rolling ..		Sept. 12, 13	April 1, May 7	March 26
Ridging ..			April 1, May 24, July 19	
Grubbing ..			June 25, July 10	

† The seeds mixture of ryegrass and white clover, previously sown under barley, was replaced in 1934-35 by ryegrass alone, sown in autumn after ploughing the barley stubble.

PLAN AND YIELDS

Wheat—AW, plots 1-25
Yields in lb., grain above, straw below.

N.W.

5 45.1 79.4 III	2 64.5 97.0 I	1 57.3 77.7 IV	3 62.8 100.7 II	4 57.8 88.2 V
5 43.4 71.6 V	1 55.8 87.2 II	3 69.2 121.3 I	4 56.5 99.5 III	2 47.2 80.3 IV
3 44.3 64.7 V	2 44.1 64.4 III	5 50.2 80.8 II	4 52.7 109.3 IV	1 65.6 132.9 I
1 45.5 64.5 V	3 48.0 69.8 III	4 61.3 105.2 I	5 47.6 117.4 IV	2 47.6 113.9 II
4 55.7 87.8 II	1 50.2 76.8 III	5 53.0 103.5 I	3 46.2 116.8 IV	2 41.9 79.6 V

Potatoes—AP, plots 26-50
Yields in lb.

N.W.

26 3 183 V	27 2 224 I	28 5 193 II	29 4 263 IV	30 1 152 III
31 4 359 I	32 2 133 IV	33 1 148 V	34 5 181 III	35 3 129 II
36 1 224 IV	37 4 206 II	38 3 180 III	39 5 212 I	40 2 158 V
41 4 308 III	42 5 241 V	43 3 228 IV	44 2 217 II	45 1 290 I
46 2 217 III	47 4 224 V	48 3 226 I	49 1 212 II	50 5 232 IV

Ryegrass—AR, plots 51-75
Yields in lb., hay

N.W.

3 181 I	4 112 III	1 68 II	2 37 IV	5 83 V
3 100 II	4 105 V	5 104 I	2 43 III	1 36 IV
2 140 I	4 130 II	3 42 V	1 49 III	5 82 IV
5 120 II	1 115 I	3 65 III	4 109 IV	2 36 V
4 82 I	2 112 II	1 41 V	5 116 III	3 50 IV

Barley—AB, plots 76-100
Yields in lb., grain above, straw below

N.W.

4 85.6 94.9 V	2 89.0 106.0 I	5 80.6 90.9 IV	3 54.0 61.0 II	1 86.6 90.9 III
5 75.9 91.1 II	2 71.5 77.0 III	1 58.6 66.4 V	4 81.0 87.0 IV	3 97.0 109.0 I
2 62.4 70.1 IV	1 82.3 87.7 I	5 75.4 87.6 III	4 81.2 84.8 II	3 64.2 69.8 V
2 57.4 62.6 V	4 74.8 83.7 III	1 72.1 76.9 II	5 65.7 79.8 I	3 61.2 68.8 IV
5 76.8 89.7 V	2 61.1 65.9 II	3 62.3 65.2 III	1 55.5 62.5 IV	4 96.5 108.0 I

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SUMMARY OF RESULTS, 1935

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	24.0	48.7	5.31	31.5	33.5	28.4
	II	20.4	32.0	3.88	27.6	29.4	16.7
	III	18.4	28.1	2.78	33.1	34.8	12.1
	IV	21.0	28.5	4.10	21.2	23.9	8.9
	V	16.7	23.6	2.71	22.4	25.4	10.0
Manure as Adco*	I	23.6	35.6	4.10	34.0	40.5	34.5
	II	17.4	41.7	3.98	23.4	25.2	27.7
	III	16.2	23.6	3.98	27.3	29.4	10.7
	IV	17.3	29.4	2.44	23.9	26.8	9.1
	V	15.4	29.2	2.90	22.0	23.9	9.0
Manure as Straw	I	25.4	44.4	4.14	37.1	41.7	44.7
	II	23.0	36.9	2.36	20.6	23.3	24.6
	III	17.6	25.6	3.30	23.8	24.9	16.1
	IV	16.9	42.8	4.18	23.4	26.3	12.3
	V	16.2	23.7	3.35	24.6	26.7	10.4
Super.	I	22.5	38.6	6.58	36.9	41.3	20.3
	II	20.4	32.2	3.78	31.0	32.4	32.0
	III	20.7	36.5	5.64	28.6	32.0	27.6
	IV	19.3	40.1	4.82	31.0	33.3	27.0
	V	21.2	32.3	4.10	32.7	36.3	25.9
Rock Phosphate	I	19.4	37.9	3.88	25.1	30.5	25.5
	II	18.4	29.6	3.54	29.0	34.8	29.5
	III	16.5	29.1	3.32	28.8	33.5	28.7
	IV	17.4	43.0	4.25	30.8	34.8	20.3
	V	15.9	26.2	4.42	29.4	34.3	20.6

The number I denotes application of manure at the beginning of the present season (1934-35); II, application in the previous season, etc.

*The Adco treated straw was dried out in June and had to be completely re-wetted. The analysis given on p. 146 shows that the compost was particularly deficient in nitrogen (0.33%N). A reasonable figure wonld be 0.5%N.

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	Broad Red	Yeoman	Ally	
Date of Sowing	April 29	March 13	April 24	Oct. 16	April 12	Oct. 27
Manures applied	April 29	March 8	Nov. 5, April 8	Oct. 9, Mar. 19	April 5,	Oct. 26, Mar. 20
Lime applied		March 4				Oct. 18
Date of harvesting	Oct. 30-Nov. 4	Aug. 12	Crop failed	Aug. 10	Oct. 15	July 29
Previous crop	Rye	Sugar beet	Barley	Clover	Wheat	Potatoes
Cultivations—						
Ploughing	Sept. 13, Feb. 11, 12	Jan. 7-8		Sept. 15	Sept. 10, Mar. 18	Oct. 18
Harrowing	Sept. 25, 27, Oct. 13, April 24, 29	Mar. 7, 14, April 18,		Oct. 16, Mar. 21,	Sept. 27, April 2, 3, May 7, 16	Oct. 26, 27 Mar. 21
Rolling	Oct. 13, April 29, 30	Mar. 15, April 18		Mar. 26	April 2, 3, May 7	Oct. 27
Singling	June 12, 13					
Hoeing	June 3, 15, 27 July 17, 27					
Ridging					April 3, May 25, July 17	
Grubbing					June 25, July 8	

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CULTIVATIONS, ETC.—WOBURN

	Sugar Beet	Barley	Clover Hay	Wheat	Potatoes	Rye
Variety	Kuhn	Plumage Archer	Broad Red	Yeoman	Ally	
Date of sowing	April 29	March 6	May 1	Nov. 6 Resown Nov. 19	April 5	Nov. 3
Manures applied	April 29	March 7, April 5,	Nov. 7, Mar. 19,	Nov. 7, Mar. 19	April 5,	Nov. 3, Mar. 28
Lime applied		March 5				Oct. 12
Date of harvesting	Nov. 19	Aug. 6	July 24	Aug. 8	Oct. 2	July 24
Previous crop	Rye	Sugar Beet	Barley	Clover failed	Wheat	Potatoes
Cultivations—						
Ploughing	Oct. 4-5, Feb. 20	Jan. 7-10		July 20-21	Oct. 5, Mar. 4	Oct. 5-8
Harrowing	Oct. 15, 16, Mar. 19, April 3, 15, 29	Mar. 6, 19	May 1, Mar. 19	Oct. 27, Nov. 6, Mar 6, 19, 28, Apr. 15, May 2, 8,	Oct. 10, Nov. 6, Mar. 19, Apr. 3, 29 June 4	Oct. 30, Nov. 3, Mar. 6, 28, Apr. 15, May 2
Rolling	Mar. 26, Apr. 29	Mar. 6, 19	Mar. 20	Mar. 20	Mar. 26	Mar. 21
Singling	June 6-11					
Hoeing	June 4, 20, 27-30, Sept. 9-10			May 28-30	June 4, July 2,	
Ridging					April 4, 5, May 8, July 9	

Note: The green manure crop of rye immediately preceding sugar beet (see 1932 Report, p. 131) was discontinued in 1934-5, both at Rothamsted and Woburn. Thus there are now only two green manure crops, mustard after rye before sugar beet, and rye after wheat before potatoes.

ROTHAMSTED, 1935

Barley*—BB, plots 1-15
Yields in lb., grain above, straw below.

4K 109.2 132.8	1K 100.7 119.3	1N 94.6 111.4	0N 89.0 104.0	3P 101.8 126.2
0K 109.3 134.2	3K 108.6 134.9	4N 107.5 140.5	1P 103.3 122.2	2P 105.6 128.4
2K 113.4 140.6	3N 107.9 144.1	2N 107.2 123.8	4P 107.7 126.8	0P 91.9 108.6

N ↑

Potatoes—BP, plots 16-30
Yields in lb.

4P 358	0P 360	3K 400	4K 428	4N 381
1P 356	3P 366	2K 415	1N 397	0N 306
2P 398	1K 368	0K 368	3N 402	2N 370

Rye—BR, Plots 31-45
Yields in lb., grain above, straw below

3P 54.9 147.1	1P 53.7 154.3	1N 60.0 141.0	3N 51.4 156.1	4K 49.8 139.2
4P 62.2 163.8	2P 49.9 154.6	0N 60.4 149.1	0K 60.9 153.1	1K 56.0 155.0
0P 59.6 135.4	4N 51.4 159.1	2N 56.1 148.4	3K 61.0 149.0	2K 55.5 151.0

N ↑

Sugar Beet—BS, plots 46-60
Yields in lb., roots (dirty) above, tops centre, sugar percentage below

4K 472 365 18.06	1K 470 343 17.37	2N 574 584 17.28	0N 544 441 17.83	3P 503 439 17.40
2K 476 458 17.02	0K 525 566 16.79	3N 496 625 16.77	4P 525 342 17.32	2P 562 480 17.74
3K 537 528 17.74	1N 566 541 17.80	4N 566 672 17.11	1P 596 590 17.49	0P 637 626 17.63

Clover Hay—BC, plots 61-75
Crop failed

0P —	1P —	2N —	1N —	2K —
4P —	2P —	3N —	1K —	0K —
3P —	4N —	0N —	3K —	4K —

N ↑

Wheat—BW, plots 76-90
Yields in lb., grain above, straw below

0K 70.8 116.2	1K 71.1 116.9	4N 74.0 125.0	1N 65.2 110.8	1P 72.4 131.6
3K 78.8 131.2	4K 78.3 130.7	0N 64.0 94.5	3P 65.9 109.1	4P 72.9 122.6
2K 82.1 137.4	3N 80.3 131.7	2N 65.3 102.2	0P 62.8 99.7	2P 58.0 104.5

* A mistake was made in the fertiliser applications to barley at both Rothamsted and Woburn. The varying nitrogen dressings were applied to the five plots which should have had varying quantities of potash, and *vice versa*. The rate of application of potash to the barley was also too high. A unit dressing was 0.374 cwt. K_2O per acre instead of 0.25 cwt. The rates of application of N and P_2O_5 were correct. The plan shows the actual treatments which were given.

WOBURN, 1935

Clover Hay—CC, Plots 1-15
Yields in lb., green weights

N.W. ↑

3K 141.0	0K 115.0	4P 170.0	3P 130.0	4N 75.0
4K 215.0	1K 100.0	1P 166.0	1N 176.0	3N 68.0
2K 58.5	0P 70.0	2P 128.0	2N 125.0	0N 153.0

Wheat—CW, Plots 16-30
Yields in lb., grain above, straw below

3N 40.2 65.2	1N 17.9 27.1	0P 33.7 53.5	4P 35.0 58.0	3K 34.7 57.0
2N 31.7 51.0	0N 11.5 14.0	2P 34.0 51.0	1K 38.2 55.0	0K 42.0 65.5
4N 46.2 80.5	3P 37.7 57.0	1P 38.7 60.0	4K 44.0 69.0	2K 39.2 60.5

Barley*—CB, Plots 31-45
Yields in lb., grain above, straw below

N.W. ↑

4N 67.0 92.5	0N 44.2 54.7	4P 73.5 91.5	2P 80.5 103.5	2K 80.2 100.2
1N 49.5 53.0	3N 69.2 83.2	1P 74.7 85.0	1K 79.7 94.7	3K 85.0 93.0
2N 61.2 63.0	3P 63.0 69.0	0P 69.5 75.5	0K 71.2 78.0	4K 74.0 84.0

Rye—CR, Plots 46-60
Yields in lb., grain above, straw below

2P 43.5 85.7	1P 48.0 92.2	4K 49.0 91.7	1K 55.5 102.7	1N 43.0 77.7
3P 50.0 90.7	4P 47.0 87.7	2K 52.0 104.7	4N 62.5 123.7	0N 40.5 68.7
0P 49.5 88.2	3K 47.0 87.7	0K 55.0 105.7	2N 55.2 104.7	3N 57.0 110.7

Potatoes—CP, Plots 61-75
Yields in lb.

N.W. ↑

2P 389	1P 356	3N 441	0N 381	4K 437
0P 356	3P 372	1N 409	2K 451	1K 381
4P 393	4N 372	2N 366	0K 409	3K 384

Sugar Beet—CS, Plots 76-90
Yields in lb., roots (dirty) above, tops centre, sugar percentage below

1N 395 309 15.81	2N 375 301 15.66	0P 477 356 15.95	1P 505 337 15.66	2K 441 326 15.61
3N 441 331 15.52	0N 373 296 15.75	4P 531 373 15.66	1K 543 363 16.21	0K 456 304 15.12
4N 510 283 15.70	2P 507 340 15.92	3P 530 346 15.72	3K 485 325 16.16	4K 431 341 16.07

* Error in manuring (see p. 163).

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ROTHAMSTED, 1935

1.—Mean yields per acre and increments in yield per cwt. of N, P_2O_5 and K_2O.

		Average, 1930-34	1935	Standard error, 1935
Sugar Beet Roots (washed) tons	Yield	6.72	8.56	
	N	0.81	−0.28	±1.10
	P	0.24	**−3.38**	±1.10
	K	0.27	−0.24	±0.66
Tops tons	Yield	8.71	9.05	
	N	3.06	**6.51**	±2.39
	P	−0.30	**−8.56**	±2.39
	K	−0.48	−1.55	±1.43
Sugar percentage	Mean	16.81	17.42	
	N	−0.23	**−1.65**	±0.50
	P	−0.68	−0.47	±0.50
	K	0.39	**1.16**	±0.30
Total Sugar cwt.	Yield	23.3	29.8	
	N	2.4	−3.8	—
	P	−0.2	−12.7	—
	K	1.6	1.0	—
Barley§ Grain cwt.	Yield	26.7	37.1	
	N	4.0	**11.9**	±3.5
	P	3.6	7.3	±3.5
	K	0.7	0.7	±1.4
Straw cwt.	Yield	31.3	45.2	
	N	9.9	**25.3**	±5.3
	P	7.9	9.7	±5.3
	K	3.3	1.2	±2.1

		Average, 1930-34	1935	Standard error, 1935
Clover Hay Dry matter cwt.	Yield	19.5*	**	
	N	15.8*		
	P	−0.4*		
	K	1.2*		
Wheat Grain cwt.	Yield	24.6	25.3	
	N	2.7†	8.4	±4.1
	P	0.4	3.3	±4.1
	K	1.2	3.2	±2.5
Straw cwt.	Yield	47.9	42.0	
	N	20.1†	**19.3**	±8.3
	P	1.8	5.6	±8.3
	K	1.7	6.2	±5.0
Potatoes tons	Yield	6.47	6.75	
	N	1.87	1.85	±0.93
	P	0.98	0.07	±0.93
	K	3.26	1.08	±0.56
Rye Grain cwt.	Yield	30.2‡	20.1	
	N	3.5‡	−6.3	±3.1
	P	0.6‡	1.5	±3.1
	K	1.2‡	−2.5	±1.9
Straw cwt.	Yield	49.3‡	53.7	
	N	2.4‡	8.4	±4.4
	P	4.4‡	**11.7**	±4.4
	K	−2.8‡	−4.9	±2.7

*4 years only, 1933 crop failed. §Error in manuring (see p. 163). † 1931-34. ‡1934 only. **crop failed. 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 error, 1935
	Average, 1930-34	1935	Average, 1930-34	1935	Average, 1930-34	1935	
Sugar Beet—Roots (washed)	1.35	−0.49	0.82	−5.92	1.61	−0.71	±1.92
Tops	5.60	**10.79**	−0.61	**−14.19**	−0.56	−4.28	±3.96
Sugar percentage	0.26	**−1.42**	−0.41	−0.41	0.58	**1.67**	±0.43
Total sugar	1.09	−1.92	0.19	−6.37	2.27	0.85	—
Barley§—Grain	2.69	**4.82**	2.18	2.94	0.69	0.75	±1.42
Straw	5.06	**8.39**	3.83	3.21	2.62	1.02	±1.75
Clover Hay—Dry matter	9.92*	—	−3.90*	—	0.80*	—	—
Wheat—Grain	2.92†	4.99	0.38	1.94	0.99	3.20	±2.45
Straw	7.36†	**6.90**	0.30	2.00	0.52	3.67	±2.98
Potatoes	4.39	4.10	2.51	0.15	12.34	4.01	±2.06
Rye—Grain	1.72‡	−4.68	0.33‡	1.10	1.02‡	−3.09	±2.33
Straw	0.73‡	2.34	1.34‡	**3.28**	−1.40‡	−2.27	±1.24

*4 years only, 1933 crop failed. §Error in manuring (see p. 163). †1931-34. ‡1934 only. Significant results in heavy type. Negative sign means depression.

WOBURN, 1935

1.—Mean yields per acre and increments in yield per cwt. of N, P_2O_5 and K_2O.

		Average, 1930-34	1935	Standard error, 1935			Average, 1930-34	1935	Standard error, 1935
Sugar Beet Roots (washed) tons	Yield	7.12	6.38		**Clover Hay** Dry matter cwt.	Yield	24.6**	12.3	
	N	3.31	**2.91**	±0.98		N	−9.2**	−17.2	±7.9
	P	−1.24	1.21	±0.98		P	−8.4**	10.7	±7.9
	K	1.09	−0.59	±0.58		K	7.5**	9.4	±4.8
Tops tons	Yield	6.71	5.87		**Wheat** Grain cwt.	Yield	9.2†	12.5	
	N	2.45	−0.05	±0.76		N	12.0†	**21.9**	±2.4
	P	−0.29	0.51	±0.76		P	−1.3†	0.5	±2.4
	K	2.00	0.26	±0.46		K	−1.0†	0.1	±1.4
Sugar percentage	Mean	17.06	15.77		Straw cwt.	Yield	23.6†	19.6	
	N	−1.17	−0.26	±0.55		N	28.0†	**40.8**	±3.5
	P	0.03	−0.35	±0.55		P	−2.2†	1.5	±3.5
	K	0.79	**0.74**	±0.33		K	−4.3†	1.3	±2.1
Total Sugar cwt.	Yield	24.3	20.1		**Potatoes** tons	Yield	9.19	7.02	
	N	9.7	8.8			N	4.74	0.17	±1.11
	P	−4.2	3.3			P	0.68	1.07	±1.11
	K	4.8	−1.0			K	0.80	0.42	±0.66
Barley* Grain cwt.	Yield	22.5	24.8		**Rye** Grain cwt.	Yield	23.1‡	18.0	
	N	18.7	**15.5**	±4.6		N	0.8‡	**13.7**	±2.0
	P	1.3	−0.9	±4.6		P	−7.0‡	−0.7	±2.0
	K	3.0	1.0	±1.8		K	−0.6‡	**−2.9**	±1.2
Straw cwt.	Yield	40.1	29.1		Straw cwt.	Yield	35.8‡	33.9	
	N	25.4	**25.2**	±8.5		N	4.5‡	**34.1**	±3.5
	P	−0.9	3.7	±8.5		P	−7.9‡	−0.6	±3.5
	K	4.9	1.0	±3.4		K	−1.8‡	**−6.2**	±2.1

*Error in manuring (see p. 163). †1931-34. ‡1934 only. **1931-33. 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 error, 1935
	Average, 1930-34	1935	Average, 1930-34	1935	Average, 1930-34	1935	
Sugar Beet—Roots (washed)	5.97	**6.85**	−2.38	2.85	4.56	−2.30	±2.29
Tops	5.27	−0.12	−0.65	1.29	6.93	1.09	±1.96
Sugar percentage	−0.67	−0.25	0.04	−0.33	1.15	**1.17**	±0.52
Total sugar	5.05	6.56	−2.33	2.48	5.52	−1.19	
Barley*—Grain	13.21	**9.35**	0.66	−0.56	3.77	1.57	±2.76
Straw	9.83	**13.01**	−0.19	1.93	2.90	1.31	±4.39
Clover Hay—Dry matter	−5.58**	−20.94	−4.94**	13.07	7.39**	19.16	±9.66
Wheat—Grain	15.30†	**26.27**	−2.40†	0.56	0.94†	0.16	±2.83
Straw	16.93†	**31.18**	−2.11†	1.12	−0.08†	1.63	±2.71
Potatoes	8.47	0.36	0.47	2.28	1.86	1.51	±2.36
Rye—Grain	0.52‡	**11.46**	−4.55‡	−0.56	−0.61‡	**−4.00**	±1.63
Straw	1.90‡	**15.08**	−3.30‡	−0.26	−1.23‡	**−4.55**	±1.57

*Error in manuring (see p. 163). **1931-33. †1931-34. ‡1934 only. Significant results in heavy type. Negative sign means depression.

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THREE COURSE ROTATION EXPERIMENT ROTHAMSTED, 1935

EFFECT OF PLOUGHING IN STRAW AND OF WINTER GREEN-MANURE CROPS

For details see 1933 Report, p. 118.

CULTIVATIONS, ETC.

	Barley	Sugar Beet	Potatoes
Variety ..	Plumage Archer	Kuhn	Ally
Date of sowing	March 13	April 29	April 12
Manures applied			
Artificials ..	October 19, March 7	September 11, April 29	November 2, April 6-8
Adco and Straw	October 19	September 11	November 2
Date of Harvesting	August 12	October 22-23	October 15
Previous crop ..	Potatoes	Barley	Sugar Beet
Cultivations—			
Ploughing ..	October 19-20, February 19-20	September 11-12, April 1	November 3, March 20-21
Harrowing ..	October 27, March 13	September 25, 27, April 24, 29	November 5, April 2, 3, May 7, 16
Rolling ..	October 27, March 15	September 27, April 29	April 2, 3, May 7
Singling ..		June 13-14	
Hoeing ..		June 15, 27, July 17, 27	July 9
Ridging ..			April 3, May 24, July 19
Grubbing ..			June 25, July 9

GREEN MANURE CROPS—GREEN WEIGHTS—TONS PER ACRE

Preceding		Manured 1934-35 Art'ls.	Adco	St. 1	St. 2	*Mean*	Manured 1933-34 Art'ls.	Adco	St. 1	St. 2	*Mean*
Barley	Vetches	0.58	0.51	0.64	0.64	*0.59*	0.71	0.59	0.78	0.75	*0.71*
	Rye ..	1.79	1.72	1.49	1.77	*1.69*	2.13	1.51	1.63	1.88	*1.79*
Sugar Beet	Vetches	0.49	0.53	0.62	0.51	*0.54*	0.36	0.34	0.45	0.60	*0.44*
	Rye ..	3.67	5.60	2.30	4.21	*3.94*	4.64	3.28	3.92	5.24	*4.27*
Potatoes	Vetches	0.27	0.44	0.29	0.39	*0.35*	0.30	0.24	0.30	0.34	*0.30*
	Rye ..	1.46	1.10	0.94	1.32	*1.20*	1.66	1.52	1.49	1.60	*1.57*

PERCENTAGE DRY MATTER

Preceding		Sample 1	Sample 2
Barley ..	Vetches	5.92	7.22
	Rye	9.96	8.71
Sugar Beet	Vetches	8.16	8.33
	Rye	12.94	13.51
Potatoes ..	Vetches	6.52	9.91
	Rye	13.80	14.15

For each break of the rotation, two large samples each of rye and vetches were taken for dry matter determination. These were weighed fresh, dried at 100°C, cleaned from soil as far as possible and weighed again. The dry matter percentages thus include a dirt tare correction.

PLAN AND YIELDS

Barley—DB, Plots 49-72. Yields in lb. grain above, straw below.

St 1 R I 86.8 110.2	**Ad R I** 84.5 100.2	**Ad V II** 87.5 106.5	**Ad V I** 83.2 99.3	**Ad R II** 72.9 78.6	**St 1 V I** 87.8 105.2
St 1 O I 89.4 107.1	**St 2 V II** 87.0 110.0	**St 1 V II** 88.9 103.6	**St 2 V I** 85.2 109.6	**St 2 R I** 84.3 88.8	**St 2 O I** 88.6 94.5
Ar R I 83.8 103.2	**Ar R II** 76.9 82.0	**Ar O I** 84.1 109.9	**Ad O I** 82.1 91.2	**St 1 O II** 84.5 97.0	**Ar V II** 82.0 103.1
St 1 R II 73.1 84.9	**Ad O II** 79.7 90.9	**St 2 R II** 73.3 81.7	**St 2 O II** 80.1 94.9	**Ar V I** 65.2 117.8	**Ar O II** 80.5 96.2

Sugar Beet—DS, Plots 25-48. Yields in lb. roots (dirty) above, tops centre, sugar percentage below.

St 1 O II 551 412 17.46	**Ad O I** 522 396 18.18	**Ad R II** 507 344 18.32	**Ar V II** 564 390 18.35	**Ar R I** 569 476 17.95	**St 2 O I** 560 438 18.01
St 2 O II 507 517 17.37	**Ad V II** 538 522 17.63	**St 2 R I** 572 433 19.24	**St 2 V I** 614 486 18.35	**St 1 R II** 540 350 18.64	**Ar O I** 561 480 17.77
Ar R II 446 451 17.98	**Ad O II** 528 542 17.92	**St 2 R II** 522 351 18.58	**St 1 V I** 594 466 18.35	**St 1 R I** 540 374 18.69	**Ad V I** 496 340 18.24
Ad R I 489 330 17.98	**Ar V I** 447 472 17.23	**St 1 O I** 442 436 17.72	**Ar O II** 429 340 18.29	**St 2 V II** 449 378 18.15	**St 1 V II** 428 352 18.15

Potatoes—DP, Plots 1-24. Yields in lb.

St 1 R II 274	**St 2 R I** 336	**Ar R I** 300	**St 2 O II** 246	**Ar O II** 200	**Ad O I** 337
St 1 O I 382	**St 2 R II** 308	**St 1 O II** 248	**Ar V II** 211	**Ad O II** 245	**St 2 O I** 302
Ar R II 248	**St 2 V II** 256	**Ar V I** 348	**St 1 R I** 384	**Ad R I** 280	**St 1 V II** 243
Ad V II 330	**Ar O I** 322	**Ad V I** 239	**St 2 V I** 324	**St 1 V I** 342	**Ad R II** 251

SUMMARY OF RESULTS

		Manured 1934-35					Manured 1933-34				
		Artificials.	Adco.*	Straw. St. 1	Straw. St. 2.	*Mean.*	Artificials.	Adco.	Straw. St. 1	Straw. St. 2	*Mean.*
Barley Grain cwt. p.a.	None	37.6	36.7	39.9	39.6	*38.4*	35.9	35.6	37.7	35.8	*36.2*
	Vetches	29.1	37.2	39.2	38.1	*35.9*	36.6	39.1	39.7	38.8	*38.6*
	Rye	37.4	37.8	38.8	37.6	*37.9*	34.4	32.6	32.6	32.7	*33.1*
	Mean	*34.7*	*37.2*	*39.3*	*38.4*	*37.4*	*35.6*	*35.8*	*36.7*	*35.8*	*36.0*
Straw cwt. p.a.	None	49.1	40.8	47.8	42.2	*45.0*	43.0	40.6	43.3	42.4	*42.3*
	Vetches	52.6	44.4	47.0	49.0	*48.2*	46.0	47.6	46.3	49.1	*47.2*
	Rye	46.1	44.7	49.2	39.7	*44.9*	36.6	35.1	37.9	36.5	*36.5*
	Mean	*49.3*	*43.3*	*48.0*	*43.6*	*46.0*	*41.9*	*41.1*	*42.5*	*42.7*	*42.0*
Sugar Beet Roots (Washed) Tons p.a.	None	11.22	10.44	8.84	11.20	*10.42*	8.58	10.56	11.02	10.14	*10.08*
	Vetches	8.94	9.92	11.88	12.29	*10.76*	11.28	10.76	8.56	8.98	*9.90*
	Rye	11.38	9.78	10.80	11.44	*10.85*	8.92	10.14	10.80	10.44	*10.08*
	Mean	*10.51*	*10.05*	*10.51*	*11.64*	*10.68*	*9.59*	*10.49*	*10.13*	*9.85*	*10.02*
Tops Tons p.a.	None	10.71	8.84	9.73	9.78	*9.76*	7.59	12.10	9.20	11.54	*10.11*
	Vetches	10.54	7.59	10.40	10.85	*9.84*	8.70	11.65	7.86	8.44	*9.16*
	Rye	10.62	7.37	8.35	9.66	*9.00*	10.07	7.68	7.81	7.83	*8.35*
	Mean	*10.62*	*7.93*	*9.49*	*10.10*	*9.53*	*8.79*	*10.48*	*8.29*	*9.27*	*9.21*
Sugar percentage	None	17.77	18.18	17.72	18.01	*17.92*	18.29	17.92	17.46	17.37	*17.76*
	Vetches	17.23	18.24	18.35	18.35	*18.04*	18.35	17.63	18.15	18.15	*18·07*
	Rye	17.95	17.98	18.69	19.24	*18.46*	17.98	18.32	18.64	18.58	*18.38*
	Mean	*17.65*	*18.13*	*18.25*	*18.53*	*18.14*	*18.21*	*17.96*	*18.08*	*18.03*	*18.07*
Total sugar cwt. p.a.	None	39.9	38.0	31.3	40.3	*37.4*	31.4	37.8	38.5	35.2	*35.7*
	Vetches	30.8	36.2	43.6	45.1	*38.9*	41.4	37.9	31.1	32.6	*35.8*
	Rye	40.8	35.2	40.4	44.0	*40.1*	32.1	37.2	40.3	38.8	*37.1*
	Mean	*37.2*	*36.5*	*38.4*	*43.1*	*38.8*	*35.0*	*37.6*	*36.6*	*35.5*	*36.2*
Potatoes Tons p.a.	None	7.19	7.52	8.53	6.74	*7.50*	4.46	5.47	5.54	5.49	*5.24*
	Vetches	7.77	5.33	7.63	7.23	*6.99*	4.71	7.37	5.42	5.71	*5.80*
	Rye	6.70	6.25	8.57	7.50	*7.26*	5.54	5.60	6.12	6.87	*6.03*
	Mean	*7.22*	*6.37*	*8.24*	*7.16*	*7.25*	*4.90*	*6.15*	*5.69*	*6.02*	*5.69*

*The Adco treated straw was dried out in June and had to be completely re-wetted. The analysis given on page 146 shows that the compost was particularly deficient in nitrogen (0.33% N). A reasonable figure would be 0.5% N.

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LONG PERIOD CULTIVATION EXPERIMENT, 1935

LONG HOOS V

(For details see 1934 Report, p. 175)

CULTIVATIONS, ETC.

	Wheat	Mangolds	Barley
Variety	Victor	Yellow Globe	Plumage Archer
Date of sowing	Oct. 19	May 1	Mar. 23
Manures applied—			
Cyanamide	Mar. 20	April 30	Mar. 13
Nitro-chalk	Mar. 20	July 4	Mar. 13
Super. & mur. pot.	—	April 30	—
Date of harvesting	Aug. 10	Oct. 29	Aug. 12
Previous crop	Barley	Wheat	Mangolds
Cultivations—			
Ploughing	Sept. 26	Mar. 25	Nov. 27, Mar. 12
Simaring	Sept. 26	Mar. 25	Mar. 12
Cultivating	Sept. 26	Mar. 25	Nov. 27, Mar. 12
Harrowing	Oct. 19, Mar. 21	April 3, 18, May 1	Mar. 18, 20, 22, 23
Hoeing	—	June 3, 11, July 4, 18	—
Rolling	Mar. 26	May 1	Mar. 22, 25
Singling	—	June 25, 26	—

PLAN AND YIELDS IN LB.

Barley

Grain left, straw right

1	P D Cy	57.2	65.3	C D N	61.9	74.6	73
	P Sh Cy	52.9	59.6	S D N	62.7	71.3	
	S D N	60.5	66.5	S Sh Cy	57.3	62.7	
	C Sh N	58.6	66.4	P D Cy	60.3	66.2	
	S Sh Cy	51.7	55.8	S Sh N	59.2	67.3	
	C D N	56.5	64.5	P D N	61.5	73.0	
B	S D Cy	57.1	59.9	P Sh N	58.3	68.2	A
	C Sh Cy	57.4	63.1	S D Cy	59.7	64.3	
	C D Cy	61.1	67.9	C D Cy	62.1	66.9	
N ↑	S Sh N	61.2	66.8	C Sh N	60.5	68.5	
	P Sh N	60.6	67.9	C Sh Cy	55.7	61.3	
	P D N	58.9	69.6	P Sh Cy	59.2	68.8	
	C Sh N	60.1	67.4	C D Cy	56.2	63.8	
	S Sh Cy	60.9	67.1	P Sh Cy	68.3	75.7	
	P D Cy	63.9	74.6	S D Cy	67.5	80.0	
	C D Cy	65.5	73.0	P D Cy	64.9	78.6	
	C Sh Cy	58.9	66.6	S Sh N	64.6	74.4	
	P Sh Cy	62.0	65.5	C Sh Cy	65.8	72.7	
C	S Sh N	60.4	67.6	S D N	65.4	71.6	C
	C D N	59.3	62.7	C D N	63.2	67.3	
	S D N	57.7	63.8	P Sh N	63.6	71.9	
	P Sh N	62.7	71.3	P D N	68.1	80.4	
	S D Cy	57.2	60.3	S Sh Cy	61.4	68.1	
	P D N	48.6	56.4	C Sh N	47.9	51.6	

Mangolds

Roots left, tops right

	S Sh N	253	84	S Sh N	296	82	
	C Sh N	334	92	S D Cy	326	72	
	C Sh Cy	260	71	P Sh Cy	349	84	
	P D N	424	90	P Sh N	404	101	
	C D N	416	88	P D Cy	462	96	
C	P Sh Cy	429	98	C D Cy	354	70	C
	C D Cy	411	83	S D N	394	89	
	S D Cy	420	85	P D N	408	81	
	P Sh N	422	102	S Sh Cy	294	66	
	S Sh Cy	376	76	C Sh N	96	50	
	S D N	431	88	C D N	320	86	
	P D Cy	428	94	C Sh Cy	209	76	
	S Sh Cy	398	92	S Sh N	270	80	
	P D N	420	94	S D N	330	88	
	P D Cy	355	78	P Sh Cy	365	86	
	P Sh Cy	365	81	C Sh N	372	92	
	C D Cy	379	88	P Sh N	346	94	
	S D Cy	406	85	P D Cy	272	69	
A	C D N	386	92	S D Cy	343	80	B
	C Sh Cy	350	72	C D N	291	82	
	P Sh N	400	94	C Sh Cy	278	70	
	C Sh N	337	92	C D Cy	288	76	
	S D N	366	91	S Sh Cy	326	82	
	S Sh N	334	99	P D N	373	96	

Wheat

Grain left, straw right.

	C Sh N	19.9	37.1	C Sh Cy	26.9	38.1	
	S Sh N	36.8	64.2	C D Cy	33.0	52.0	
	P Sh Cy	41.5	62.0	C Sh N	29.7	54.6	
	C D Cy	36.8	57.2	P D N	35.7	55.6	
	C Sh Cy	33.0	58.5	C D N	36.6	54.9	
	C D N	29.5	66.0	S Sh Cy	33.0	47.0	A
C	S Sh Cy	33.9	57.1	S D N	39.3	62.7	
	S D Cy	31.0	52.0	P Sh Cy	33.9	54.1	
	P D Cy	35.0	55.0	S D Cy	31.8	53.7	
	P Sh N	35.5	58.0	P D Cy	35.1	53.4	
	P D N	35.5	56.5	P Sh N	35.8	59.7	
	S D N	30.1	61.4	S Sh N	33.1	55.9	
	S Sh Cy	32.0	56.0	S D Cy	38.4	57.1	
	C D Cy	27.5	54.0	C D Cy	38.0	55.8	
	C Sh Cy	27.3	52.2	C Sh Cy	38.2	53.3	
	P Sh Cy	32.3	51.7	P Sh N	41.1	78.9	
	C Sh N	32.1	57.2	C D N	38.0	53.5	
B	S Sh N	39.3	62.2	S Sh N	38.6	58.4	C
	C D N	37.1	67.9	S D N	35.0	57.5	
	P D Cy	41.4	57.1	S Sh Cy	39.2	60.3	
	S D N	41.3	65.7	P D Cy	40.4	58.1	
	P D N	46.1	72.9	P D N	41.3	67.2	
	S D Cy	40.6	65.9	C Sh N	43.6	72.4	
72	P Sh N	49.3	76.2	P Sh Cy	48.3	71.7	144

Summary of Results

Last year	Continuous P P	Continuous S S	Continuous C C	*Mean*	Cycle A C P	Cycle A P S	Cycle A S C	Cycle B S P	Cycle B C S	Cycle B P C	*Mean*
WHEAT				GRAIN : cwt. per acre							
N D	22.3	18.9	19.6	20.3	20.7	22.8	21.2	26.8	24.0	21.5	22.8
N Sh	22.2	21.9	18.4	20.8	20.8	19.2	17.2	28.6	22.8	18.6	21.2
Cy D	21.9	20.1	21.7	21.2	20.4	18.4	19.2	24.0	23.6	16.0	20.3
Cy Sh	26.0	21.2	20.7	22.6	19.7	19.2	15.6	18.7	18.6	15.8	17.9
St. errors		±1.65		±0.953							
				STRAW : cwt. per acre							
N D	35.9	34.5	34.7	35.0	32.2	36.4	31.9	42.3	38.1	39.4	36.7
N Sh	39.7	35.6	31.8	35.7	34.6	32.4	31.6	44.2	36.1	33.2	35.4
Cy D	32.8	31.6	32.8	32.4	31.0	31.2	30.2	33.1	38.2	31.3	32.5
Cy Sh	38.8	34.1	32.4	35.1	31.4	27.3	22.1	30.0	32.5	30.3	28.9
St. errors		±3.79		±2.19							
MANGOLDS				ROOTS : tons per acre							
N D	24.14	23.94	21.36	23.15	24.37	21.24	22.40	21.65	19.15	16.89	20.95
N Sh	23.97	15.93	12.48	17.46	23.21	19.38	19.56	20.08	15.67	21.59	19.92
Cy D	25.82	21.65	22.20	23.22	20.60	23.56	22.00	15.78	19.91	16.71	19.76
Cy Sh	22.58	19.44	13.61	18.54	21.18	23.10	20.31	21.18	18.92	16.13	20.14
St. errors		±2.12		±1.22							
				TOPS : tons per acre							
N D	4.96	5.14	5.03	5.04	5.48	5.28	5.37	5.54	5.08	4.76	5.25
N Sh	5.90	4.83	4.11	4.95	5.43	5.74	5.31	5.46	4.61	5.34	5.32
Cy D	5.50	4.57	4.45	4.84	4.53	4.93	5.08	4.00	4.64	4.41	4.60
Cy Sh	5.28	4.12	4.28	4.56	4.70	5.34	4.18	5.02	4.76	4.09	4.68
St. errors		±0.366		±0.211							
BARLEY				GRAIN : cwt. per acre							
N D	33.9	35.7	35.5	35.0	35.7	36.4	35.9	34.2	35.1	32.8	35.0
N Sh	36.6	36.3	31.3	34.7	33.8	34.4	35.1	35.2	35.5	34.0	34.7
Cy D	37.4	36.2	35.3	36.3	35.0	34.6	36.0	33.2	33.1	35.4	34.6
Cy Sh	37.8	35.5	36.2	36.5	34.4	33.2	32.3	30.7	30.0	33.3	32.3
St. errors		±2.43		±1.40							
				STRAW : cwt. per acre							
N D	39.7	39.3	37.7	38.9	42.4	41.4	43.3	40.4	38.6	37.4	40.6
N Sh	41.6	41.2	34.5	39.1	39.6	39.0	39.8	39.4	38.8	38.5	39.2
Cy D	44.4	40.7	39.7	41.6	38.4	37.3	38.8	37.9	34.8	39.4	37.8
Cy Sh	41.0	39.2	40.4	40.2	39.9	36.4	35.6	34.6	32.4	36.6	35.9
St. errors		±3.14		±1.81							

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Mean of Nitro-Chalk and Cyanamide

	Continuous				Cycle A			Cycle B			
Last Year This year	P P	S S	C C	*Mean*	C P	P S	S C	S P	C S	P C	*Mean*
WHEAT				GRAIN : cwt. per acre							
D ..	22.1[1]	19.5[1]	20.6[1]	*20.7*[3]	20.6	20.6	20.2	25.4	23.8	18.8	*21.6*
Sh ..	24.1[1]	21.6[1]	19.6[1]	*21.8*[3]	20.2	19.2	16.4	23.6	20.7	17.2	*19.6*
Mean	*23.1*[2]	*20.6*[2]	*20.1*[2]	*21.3*	*20.4*	*19.9*	*18.3*	*24.5*	*22.2*	*18.0*	*20.6*
St. errors (1) ±1.17, (2) ± 0.827, (3) ±0.676											
				STRAW : cwt. per acre							
D	34.4[1]	33.0[1]	33.8[1]	*33.7*[3]	31.6	33.8	31.0	37.7	38.2	35.4	*34.6*
Sh	39.2[1]	34.8[1]	32.1[1]	*35.4*[3]	33.0	29.8	26.8	37.1	34.3	31.8	*32.1*
Mean	*36.8*[2]	*33.9*[2]	*33.0*[2]	*34.6*	*32.3*	*31.8*	*28.9*	*37.4*	*36.2*	*33.6*	*33.4*
St. errors (1) ±2.68, (2) ±1.90, (3) ±1.55											
MANGOLDS				ROOTS : tons per acre							
D	24.98[1]	22.80[1]	21.78[1]	*23.19*[3]	22.48	22.40	22.20	18.72	19.53	16.80	*20.36*
Sh	23.28[1]	17.68[1]	13.04[1]	*18.00*[3]	22.20	21.24	19.94	20.63	17.30	18.86	*20.03*
Mean	*24.13*[2]	*20.24*[2]	*17.41*[2]	*20.59*	*22.34*	*21.82*	*21.07*	*19.68*	*18.42*	*17.83*	*20.19*
St. errors (1) ±1.50, (2) ±1.06, (3) ±0.866											
				TOPS : tons per acre							
D	5.23[1]	4.86[1]	4.74[1]	*4.94*[3]	5.00	5.10	5.22	4.77	4.86	4.58	*4.92*
Sh	5.59[1]	4.48[1]	4.20[1]	*4.76*[3]	5.06	5.54	4.74	5.24	4.68	4.72	*5.00*
Mean	*5.41*[2]	*4.67*[2]	*4.47*[2]	*4.85*	*5.03*	*5.32*	*4.98*	*5.00*	*4.77*	*4.65*	*4.96*
St. errors (1) ±0.259 (2) ±0.183, (3) ±0.150											
BARLEY				GRAIN : cwt. per acre							
D	35.6[1]	36.0[1]	35.4[1]	*35.7*[3]	35.4	35.5	36.0	33.7	34.1	34.1	*34.8*
Sh	37.2[1]	35.9[1]	33.8[1]	*35.6*[3]	34.1	33.8	33.7	33.0	32.8	33.6	*33.5*
Mean	*36.4*[2]	*36.0*[2]	*34.6*[2]	*35.6*	*34.8*	*34.6*	*34.8*	*33.4*	*33.4*	*33.8*	*34.1*
St. errors (1) ±1.72, (2) ±1.22, (3) ±0.993											
				STRAW : cwt. per acre							
D	42.0[1]	40.0[1]	38.7[1]	*40.2*[3]	40.4	39.4	41.0	39.2	36.7	38.4	*39.2*
Sh	41.3[1]	40.2[1]	37.4[1]	*39,6*[3]	39.8	37.7	37.7	37.0	35.6	37.6	*37.6*
Mean	*41.6*[2]	*40.1*[2]	*38.0*[2]	*39.9*	*40.1*	*38.6*	*39.4*	*38.1*	*36.2*	*38.0*	*38.4*
St. errors (1) ±2.22, (2) ±1.57, (3) ±1.28											

https://doi.org/10.23637/ERADOC-1-67

Conclusions

On both mangolds and wheat the plots ploughed this year and last yielded significantly higher than the cultivated plots, the simared plots being intermediate. On the wheat similar differences appeared on the plots with rotating cultivations, but in the case of the mangolds the differences, though in the same direction, were much smaller.

In addition the shallow cultivations of the continuous part of the experiment gave lower yields than the deep cultivations, this difference being most marked on the cultivated plots and only small on the ploughed plots. No such difference appeared on the plots with rotating cultivations.

The yields of barley did not appear to be affected by the cultivations.

There were no observable differences between nitro-chalk and cyanamide.

THREE COURSE ROTATION EXPERIMENT, ROTHAMSTED, 1933

GREEN MANURE CROPS—GREEN WEIGHTS—TONS PER ACRE

Preceding		Manured 1932-33					Not yet manured				
		Art'ls.	Adco	St. 1.	St. 2	*Mean*	Art'ls.	Adco	St. 1	St. 2	*Mean*
Sugar Beet	Vetches	0.55	0.65	0.56	0.70	*0.62*	0.49	0.84	0.62	0.58	*0.63*
	Rye	1.02	0.78	0.75	0.92	*0.87*	1.29	1.08	0.78	1.11	*1.06*
Potatoes	Vetches	0.32	0.27	0.34	0.41	*0.34*	0.38	0.35	0.28	0.33	*0.34*
	Rye	0.54	0.76	0.30	0.67	*0.57*	0.63	0.47	0.62	0.52	*0.56*
Barley ..	Vetches	0.26	0.20	0.14	0.20	*0.20*	0.19	0.24	0.16	0.24	*0.21*
	Rye	0.37	0.40	0.22	0.40	*0.34*	0.74	0.30	0.44	0.44	*0.48*

NOTE: These figures were omitted from the 1933 report and are included here for the sake of completeness.

WHEAT

Effect of sulphate of ammonia applied at five different times.

RW—Gt. Harpenden, 1935.

Plan and yields in lb., grain above, straw below.

W ↑

1	**4** 77.2 166.0	**0** 88.0 147.9	**2** 89.7 184.9	**1** 92.6 188.4	**3** 72.1 197.4	**5** 76.2 181.8	6
	3 93.2 190.8	**4** 95.8 193.0	**0** 94.1 168.0	**5** 93.9 198.8	**1** 91.6 191.8	**2** 67.3 197.1	
	5 90.2 169.2	**2** 87.0 185.6	**3** 86.1 185.8	**4** 85.5 205.2	**0** 93.4 184.8	**1** 68.5 180.8	
	2 72.5 188.5	**3** 76.7 191.8	**1** 96.3 174.0	**0** 95.3 172.4	**5** 95.9 189.8	**4** 78.2 168.3	
	0 84.2 161.1	**1** 96.5 185.0	**5** 98.5 177.8	**2** 81.6 201.7	**4** 90.1 191.1	**3** 81.8 168.0	
31	**1** 77.0 168.0	**5** 91.9 170.6	**4** 95.1 170.0	**3** 86.3 190.5	**2** 82.8 188.4	**0** 60.5 134.8	36

SYSTEM OF REPLICATION : 6×6 Latin square.
AREA OF EACH PLOT : 1/40 acre (63.5 lks. × 39.4 lks.)
TREATMENTS : No sulphate of ammonia (**0**) and sulphate of ammonia at the rate of 0.4 cwt. N per acre, applied on Oct. 26 (**1**), Jan. 19 (**2**), Mar. 18 (**3**), Apr. 27 (**4**) and May 24 (**5**).
CULTIVATIONS, ETC. Ploughed : Sept. 15-20. Harrowed : Oct. 24. Drilled : Oct. 26. Harrowed : Oct. 27. Harvested : Aug. 8 and 9. Variety : Victor. Previous crop : Beans.
STANDARD ERRORS PER PLOT : Grain : 2.35 cwt. per acre or 7.67% ; Straw 2.63 cwt. per acre or 4.08%.

Summary of results : cwt. per acre.

	No N	Dates of application of sulphate of ammonia (0.4 cwt. N per acre) Oct. 26	Jan. 19	Mar. 18	Apr. 27	May 24	*Mean of all N.*	*St. error*
GRAIN (±0.960)	30.7	31.1	28.6	29.5	31.1	32.5	*30.6*	*±0.429*
Incr. (*±1.36*)		*+0.4*	*−2.1*	*−1.2*	*+0.4*	*+1.8*	*−0.1*	*±1.05*
STRAW (±1.07)	57.7	64.8	68.2	66.9	65.1	64.8	*66.0*	*±0.478*
Incr. (*±1.51*)		*+7.1*	*+10.5*	*+9.2*	*+7.4*	*+7.1*	*+8.3*	*±1.17*

Conclusions

The average response to sulphate of ammonia was significant for straw, but negligible for grain. The differences due to date of application were not significant in grain ; in straw, however, where the yields rose to a maximum and fell again, the parabolic regression of yield on time of application was significant.

SPRING OATS

RO—PASTURES, 1935

Soil fumigation experiment. Effect of "cymag," carbon disulphide jelly, chlordinitrobenzene and "seekay"

Plan and yields in lb., grain above, straw centre, weeds below

1	O 8.0 9.1 52.1	2CK 0.5 0.4 0.1	1N 5.1 6.7 14.4	1CM 29.4 39.3 6.8	2CM 28.0 50.9 2.1	2S 27.8 49.8 0.6	2CK 1.1 2.7 3.7	O 13.8 31.4 17.8	40
	1S 33.1 49.9 3.5	O 23.6 35.6 13.5	O 9.1 19.1 53.5	2CM 32.2 45.0 4.2	1CK 0.6 2.1 1.3	1N 9.8 17.9 17.3	1CM 23.1 40.0 11.7	O 11.2 22.3 34.0	
S	2S 28.2 44.7 6.1	1CK 0.5 1.0 3.5	O 19.5 33.6 29.9	2N 11.3 20.0 4.7	O 9.9 7.2 44.9	O 20.7 32.0 17.3	2N 8.5 20.9 5.3	1S 21.0 37.7 20.8	
	1CK 0.3 0.1 1.1	O 6.3 4.8 59.2	1S 12.5 20.8 42.4	2CK 0.3 0.2 1.4	2CK 0.0 0.0 0.5	O 11.1 6.5 61.7	1CK 0.3 0.3 0.6	1CM 25.4 47.2 4.6	
	O 10.6 12.4 35.4	2N 4.1 6.5 10.4	2S 15.8 23.8 27.6	1N 6.3 15.7 21.3	O 14.4 30.7 25.4	2N 13.2 28.6 4.4	2S 27.9 42.1 9.4	O 21.5 33.5 17.2	
21	2CM 20.4 33.1 19.7	O 11.6 25.0 40.6	1CM 10.7 22.4 43.4	O 6.6 11.6 59.8	1S 16.8 43.0 15.2	1N 15.2 29.6 11.0	O 18.1 31.8 27.0	2CM 21.9 53.6 1.5	36

The positions of the blocks in the field were slightly different from those shown above.

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

Area of Each Plot: 1/80 acre (30 lks. × 41.7 lks.).

Treatments: No fumigant (O), single (1) and double (2) dressings of "cymag" (CM), carbon disulphide jelly (S), chlordinitrobenzene (N) and "seekay" (CK), at the following rates of application per acre for the single dressing: 1 CM, 7.5 cwt.; 1 S, 24.3 cwt.; 1 N, 2.0 cwt. and 1 CK, 5.0 cwt.

Basal Manuring: 1 cwt. sulphate of ammonia per acre.

Cultivations: Ploughed: March 21 and 22. Fumigants ploughed in. Harrowed: March 25 and 26. Rolled: March 26. Drilled: March 26. Harrowed: March 27. Rolled: March 27. Harrowed: May 3. Rolled: May 3. Harvested: August 9. Variety: Marvellous. Previous crop: Spring oats.

Special Note: The ratio of weeds to total oats was determined by sampling at harvesting, two random samples being taken per plot.

Standard Errors per Plot: Grain: 3.38 cwt. per acre or 28.5%; straw: 6.17 cwt. per acre or 30.4%; weeds: 5.07 cwt. per acre.

Summary of Results

	GRAIN : cwt. per acre ($\pm$1.69. *Means:* $\pm$*1.19*)				STRAW : cwt. per acre			
	Chlor-dinitro-benzene	Carbon disulph-ide jelly	"Cymag"	"Seekay"	Chlor-dinitro-benzene	Carbon disulph-ide jelly	"Cymag"	"Seekay"
None ..	9.6[1]				15.5			
Single ..	6.5	14.9	15.8	Nil	12.5	27.0	26.6	Nil
Double ..	6.6	17.8	18.3	Nil	13.6	28.7	32.6	Nil
Mean of single and double ..	*6.6*	*16.4*	*17.0*	*Nil*	*13.0*	*27.8*	*29.6*	*Nil*

STANDARD ERROR : (1) $\pm$0.845. No single standard error is applicable to the straw yields.

	WEEDS : cwt. per acre			
	Chlor-dinitro-benzene	Carbon disulph-ide jelly	"Cymag"	"Seekay"
None ..	26.3			
Single ..	11.4	14.6	11.9	Nil
Double ..	4.4	7.8	4.9	Nil
Mean of single and double ..	*7.9*	*11.2*	*8.4*	*Nil*

Conclusions

Carbon disulphide jelly and "cymag" produced significant increases in the yield of grain, "cymag" giving slightly, but not significantly, higher yields than carbon disulphide jelly. In neither case was the falling-off in response at the higher level of dressing significant. The responses were presumably due in part at least to nitrogen, the single dressings of carbon disulphide jelly and "cymag" being equivalent to 37 and 87 lb. nitrogen per acre respectively. Chlordinitrobenzene significantly decreased the yield, but there was no apparent difference between the effects of the single and double dressings. There was practically no crop on the plots receiving "seekay," due to the short interval between application of the fumigants and the drilling of the seed.

No relation was found between the yields and the numbers of cysts at the second eelworm count after eliminating treatment effects.

The results for straw were similar to those for grain.

All fumigants produced large decreases in the weight of weeds, with a further decrease with the double dressing. The crop was unusually weedy.

M

Plan and numbers of cysts per 400 gms. of soil, first count above, second below

1	O 269 466	2CK 283 280	1N 252 398	1CM 212 386	2CM 95 199	2S 127 166	2CK 80 142	O 134 590	40
	1S 138 194	O 100 219	O 197 421	2CM 263 379	1CK 107 236	1N 89 332	1CM 41 176	O 74 137	
	2S 282 372	1CK 230 256	O 216 708	2N 145 304	O 88 356	O 25 212	2N 42 308	1S 62 221	
	1CK 124 268	O 211 505	1S 194 433	2CK 222 408	2CK 193 292	O 209 352	1CK 109 132	1CM 153 454	
	O 102 363	2N 193 561	2S 128 311	1N 42 222	O 29 254	2N 9 92	2S 17 28	O 19 106	
21	2CM 162 365	O 191 563	1CM 107 415	O 67 338	1S 23 80	1N 19 114	O 44 268	2CM 48 298	36

NOTE : First count : Mar. 8. Second count : Oct. 14. Two random samples of about 100 gms. of soil each were taken per half plot.

STANDARD ERRORS PER PLOT (400 gms. of soil) : First count : sampling error 28.1, or 21.9%. Experimental error 58.1 or 45.2%. Second count : sampling error 74.3, or 24.3%. Experimental error : 123.0, or 40.2%. Second count adjusted for first count : experimental error 84.4, or 27.6%.

Summary of results

	Second count, adjusted for first count (±42.2. *Means:* ±29.8)			
	Chlordinitrobenzene	Carbon disulphide jelly	"Cymag"	"Seekay"
None		374[1]		
Single ..	310	270	358	201
Double ..	365	203	289	178
Mean of single and double ..	*338*	*236*	*324*	*190*

STANDARD ERROR (:) (1) ±21.1.

Conclusions

Carbon disulphide jelly and "seekay" produced significant decreases in the number of cysts, the falling-off in the decrease at the higher level of dressing being small for carbon disulphide jelly and not quite significant for "seekay." The decreases due to chlordinitrobenzene and "cymag" were not significant and were significantly less than those due to the other two fumigants.

https://doi.org/10.23637/ERADOC-1-67

POTATOES

Effect of dung ploughed in and applied in the bouts, and of sulphate of ammonia and minerals broadcast before bouting and applied in the bouts.

RP—Little Hoos, 1935

Total produce in lb. above, percentage ware below

1 — 12

Dp A_2 N — 284 81.7	— A_1 — PK 216 69.9	Dp A_2 — PK 272 75.2	Dp A_1 — — 201 74.9	Dp A_2 — — 174 71.3	Db A_2 N — 269 77.1	— A_1 — PK 154 57.5	Db A_1 — — 218 72.7	— A_2 — — 120 54.6	Dp A_1 — — 218 73.2	Db A_1 N PK 187 69.5	— A_1 — PK 167 62.3
Db A_2 — — 232 76.3	Dp A_1 N PK 326 82.8	Db A_2 N PK 418 82.8	— A_1 N — 130 58.8	— A_2 N PK 293 72.4	Dp A_2 N PK 314 78.0	Db A_1 N PK 283 76.3	Db A_2 — PK 249 76.3	Dp A_1 N PK 250 79.0	Db A_1 — — 204 74.8	Db A_2 N — 262 78.4	Dp A_2 N — 221 71.0
Db A_1 N — 300 78.2	— A_2 N PK 337 78.9	— A_2 — — 214 68.0	Db A_1 — PK 280 77.1	Dp A_1 N — 260 77.5	— A_1 N — 135 50.7	Dp A_1 — PK 212 71.9	— A_2 — — 141 55.3	Dp A_2 — PK 226 71.7	Db A_2 — PK 248 75.4	— A_1 N — 132 45.4	— A_2 N PK 288 70.0
Db A_2 N — 298 79.2	Dp A_2 N PK 322 80.9	— A_2 N — 112 42.8	Dp A_2 — — 206 77.7	Dp A_2 N — 256 76.2	Dp A_1 N PK 260 76.5	Dp A_1 — — 171 70.5	Db A_1 N — 274 74.1	Db A_1 — PK 281 77.9	Db A_1 N — 355 81.1	— A_1 — — 128 43.4	Dp A_2 — — 202 71.0
Dp A_1 — PK 212 75.9	Db A_1 — — 229 73.6	— A_1 — — 129 54.6	Db A_1 N PK 296 77.7	Dp A_2 — PK 198 72.2	Db A_1 — PK 217 69.1	— A_1 — — 83 36.1	— A_2 — PK 210 68.6	Dp A_2 N PK 369 82.6	Db A_2 N PK 402 83.4	— A_2 N — 90 28.9	— A_1 N PK 245 72.2
— A_2 — PK 195 71.8	Db A_2 — PK 307 83.1	— A_1 N PK 275 75.3	Dp A_1 N — 267 83.9	— A_1 N PK 261 74.9	Db A_2 N PK 401 82.5	Db A_2 — — 252 75.2	— A_2 N — 108 38.0	Dp A_1 N — 296 81.2	— A_2 — PK 218 64.0	Db A_2 — — 277 77.4	Dp A_1 — PK 265 74.7

61 — 72

N ↑

System of Replication : 6 randomised blocks of 12 plots each. Certain high order interactions partially confounded with block differences.

Area of Each Plot : 1/50 acre (63.5 lks. × 31.5 lks., 9 rows per plot, of which the 7 middle rows were harvested).

Treatments : All combinations of :

Dung		Artificials		Sulph. Amm.		Super. and mur. pot.
None (—) Ploughed in (Dp) In the bouts (Db)	×	broad cast before bouting (A_1) In the bouts (A_2)	×	None (—) 0.8 cwt. N. (N)	×	None (—) 0.8 cwt. P_2O_5 and 1.6 cwt. K_2O. (PK)

Cultivations, etc. : Dung applied to Dp plots : Feb. 19. Ploughed : Feb. 19-22. Artificials applied to A_1 plots : March 25. Tractor cultivated : March 26. Horse cultivated : March 27. Horse rolled : April 1. Ridged : April 2 and 3. Dung applied to Db plots : April 4. Applied artificials to A_2 plots : April 12. Potatoes planted : April 13-15. Rolled and harrowed ridges : May 7. Harrowed ridges : May 16. Re-ridged : May 24. Grubbed : June 25. Hand-hoed : July 10-11. Earthed up : July 13-14. Lifted : October 16-18. Variety : Ally. Previous crop : Wheat. Potatoes passed through a $1\frac{5}{8}$ inch riddle to determine the percentage ware.

Special Note : The potatoes were stored in a clamp from harvest till February, the different replicates of the treatments being bulked and arranged in random order in the clamp.

Standard Errors per Plot : Total produce : 0.660 tons per acre or 9.67% ; Percentage ware : 3.36.

https://doi.org/10.23637/ERADOC-1-67

Summary of Results : block effects eliminated

		No dung. No super or mur.pot.	No dung. Super and mur. pot.	Dung. No super or mur.pot.	Dung. Super and mur. pot.
TOTAL PRODUCE : tons per acre					
No sulph. amm.	Artificials broadcast before bouting	3 90[2]	5.36[1]	6.18[3]	6.78[2]
	Artificials in the bouts ..		5.75[1]		7.42[2]
Sulph. amm.	Artificials broadcast before bouting	4.02[1]	7.26[1]	8.14[2]	7.91[2]
	Artificials in the bouts ..	2.75[1]	9.00[1]	7.66[2]	10.41[2]
PERCENTAGE WARE					
No sulph. amm.	Artificials broadcast before bouting	52.0[5]	63.8[4]	74.1[6]	74.0[5]
	Artificials in the bouts ..		67.5[4]		76.2[5]
Sulph. amm.	Artificials broadcast before bouting	52.2[4]	73.5[4]	78.9[5]	77.4[5]
	Artificials in the bouts ..	36.0[4]	74.4[4]	77.7[5]	81.2[5]

STANDARD ERRORS : (1) ±0.381, (2) ±0.269, (3) ±0.190, (4) ±1.94, (5) ±1.37, (6) ±0.970. These standard errors apply to comparisons which are not confounded.

Effect of time of application of dung

	No Artificials	Sulph. amm. b'cast before bouting	Sulph. amm. in the bouts	Super and mur. pot. b'cast before bouting	Super and mur. pot. in the bouts	Sulph. amm., super and mur. pot. b'cast before bouting	Sulph. amm., super and mur. pot. in the bouts	*Mean*
TOTAL PRODUCE : tons per acre (±0.381)								
Dung ploughed in	5.60[1]	7.87	7.28	6.59	6.66	8.00	9.61	*7.15*[2]
Dung in the bouts	6.76[1]	8.89	7.93	7.44	7.69	7.33	11.68	*8.06*[2]
Difference ..	*+1.16*[3]	*+1.02*[4]	*+0.65*[4]	*+0.85*[4]	*+1.03*[4]	*−0.67*[4]	*+2.07*[4]	*+0.91*
PERCENTAGE WARE : (±1.94)								
Dung ploughed in	73.1[5]	80.9	76.3	74.2	73.0	79.4	80.5	*76.3*[6]
Dung in the bouts	75.0[5]	77.8	78.2	74.7	78.3	74.5	82.9	*77.0*[6]
Difference ..	*+1.9*[7]	*−3.1*[8]	*+1.9*[8]	*+0.5*[8]	*+5.3*[8]	*−4.9*[8]	*+2.4*[8]	*+0.7*

STANDARD ERRORS : (1) ±0.269, (2) ±0.135, (3) ±0.381, (4) ±0.539, (5) ±1.37, (6) ±0.686, (7) ±1.94, (8) ±2.74.

Conclusions : Yields

Dung applied in the bouts gave consistently 0.9 tons per acre more than dung ploughed in (in November).

There was no response to sulphate of ammonia applied alone, but in the presence of phosphate and potash or dung or both there was a response of 2.1 tons per acre.

In addition to producing a response to sulphate of ammonia, dung gave increases of 3.4 tons per acre in the absence of potash and phosphate and 1.3 tons per acre in their presence.

Sulphate of ammonia, in the complete fertiliser, gave a larger response when applied in the bouts than when broadcast before bouting, the increases being 3.1 and 1.9 tons per acre respectively. This was the only large effect of time of application of the artificials.

The response to potash and phosphate depended on the other manures present in the way indicated above; in particular the response was 3.2 tons per acre in the absence of dung, and 1.1 tons per acre in the presence of dung, and was greater when the potash and phosphate were applied in the bouts than when they were broadcast before bouting.

The effects of the treatments on percentage ware were in general similar to those on yield.

Summary of results: effect of storing in clamp

	Artificials.	No dung. No super or mur.pot.	No dung. Super and mur. pot.	Dung. No super or mur.pot.	Dung. Super and mur. pot.
		Percentage loss in weight after storing.			
No sulph. amm.	Broadcast before bouting ..	4.8	6.3	4.4	4.4
	In the bouts		2.4		5.5
Sulph. amm.	Broadcast before bouting ..	1.5	3.8	2.2	7.2
	In the bouts	1.6	1.2	6.8	6.4
		Percentage good after storing.			
No sulph.amm.	Broadcast before bouting ..	95.2	90.4	92.2	94.4
	In the bouts		94.1		91.5
Sulph. amm.	Broadcast before bouting ..	94.3	90.6	93.3	87.8
	In the bouts	98.5	95.7	94.7	93.8

Effect of time of application of dung

	No Artifi-cials	Sulph. amm. b'cast before bouting	Sulph. amm. in the bouts	Super and mur. pot. b'cast before bouting	Super and mur. pot. in the bouts	Sulph. amm. super and mur. pot. b'cast before bouting	Sulph. amm. super and mur. pot. in the bouts	*Mean*
	Percentage loss in weight after storing.							
Dung ploughed in	5.4	3.2	8.5	4.5	6.9	7.4	8.3	*6.2*
Dung in the bouts	3.3	1.2	5.2	4.4	4.1	7.0	4.4	*4.1*
Difference ..	*−2.1*	*−2.0*	*−3.3*	*−0.1*	*−2.8*	*−0.4*	*−3.9*	*−2.1*
	Percentage good after storing.							
Dung ploughed in	93.4	93.6	94.6	94.9	94.3	90.2	95.0	*93.7*
Dung in the bouts	91.0	93.0	94.8	93.8	88.7	85.4	92.5	*91.3*
Difference ..	*−2.4*	*−0.6*	*+0.2*	*−1.1*	*−5.6*	*−4.8*	*−2.5*	*−2.4*

Conclusions: Storing

The average loss in weight on storing was 4 per cent. The loss was about 2 per cent. greater where dung was ploughed in than where it was applied in the bouts. There were no other treatment effects.

About 7 per cent. of the potatoes went bad on storing. Dung increased the percentage going bad, by 2 per cent. the increase being consistently greater with dung in the bouts than with dung ploughed in. Minerals increased the percentage going bad by 0.8 per cent. Sulphate of ammonia had on the average little effect, though there are indications that the percentage going bad was higher when the sulphate of ammonia was broadcast before bouting than when it was applied in the bouts.

SUGAR BEET

Effect of sowing date, spacing of rows and of sulphate of ammonia

RS—LITTLE HOOS, 1935

Plan and yields in lb.

				Roots (dirty)	Tops	Sugar per cent.	Plant number					Roots (Dirty)	Tops	Sugar per cent.	Plant number	
27	1	S_{15}	N_2	566	348	16.70	833		2	S_{20}	N_1	522	359	16.79	527	54
	3	S_{10}	N_2	537	482	16.50	1,378		2	S_{10}	—	579	371	16.88	1,333	
	1	S_{10}	N_1	553	314	17.00	1,420		2	S_{15}	N_2	542	372	16.39	764	
	3	S_{15}	—	362	244	17.05	914		1	S_{10}	N_2	686	444	16.18	1,377	
	1	S_{20}	—	398	220	16.50	558		3	S_{15}	—	434	286	16.88	875	
	2	S_{20}	N_2	531	400	16.79	507		1	S_{15}	N_1	626	382	16.53	799	
	2	S_{15}	N_1	493	292	17.05	789		1	S_{20}	—	489	257	16.21	541	
	2	S_{10}	—	501	294	16.85	1,171		3	S_{20}	N_2	458	432	16.39	530	
	3	S_{20}	N_1	425	353	16.36	510		3	S_{10}	N_1	622	453	16.39	1,424	
	3	S_{10}	N_1	522	359	16.53	1,391		3	S_{15}	N_1	585	426	16.43	855	
	1	S_{10}	—	486	265	16.79	1,453		3	S_{10}	N_2	688	648	16.42	1,399	
	1	S_{15}	N_1	500	284	17.05	878	E	2	S_{20}	N_2	566	368	16.30	542	
	1	S_{20}	N_2	527	342	15.98	566	↑	1	S_{15}	N_2	656	436	16.10	796	
	2	S_{10}	N_2	636	466	16.79	1,315		3	S_{20}	—	486	324	17.08	539	
	3	S_{20}	—	477	333	16.56	513		1	S_{20}	N_1	520	298	16.36	520	
	3	S_{15}	N_2	486	486	16.59	783		1	S_{10}	—	566	303	16.47	1,351	
	2	S_{15}	—	448	312	16.62	836		2	S_{10}	N_1	594	344	16.33	1,348	
	2	S_{20}	N_1	499	300	16.44	531		2	S_{15}	—	487	272	16.44	802	
	3	S_{20}	N_2	464	396	16.21	526		2	S_{10}	N_2	754	486	16.44	1,286	
	3	S_{10}	—	460	392	16.59	1,441		3	S_{15}	N_2	578	487	16.42	859	
	2	S_{10}	N_1	516	355	16.47	1,361		3	S_{10}	—	524	358	16.27	1,445	
	3	S_{15}	N_1	458	378	16.96	871		2	S_{15}	N_1	393	220	16.04	744	
	1	S_{15}	—	467	261	16.30	843		1	S_{20}	N_2	484	248	16.56	549	
	2	S_{15}	N_2	520	424	16.13	688		1	S_{15}	—	515	276	16.33	821	
	2	S_{20}	—	440	260	16.65	556		2	S_{20}	—	424	234	17.05	542	
	1	S_{10}	N_2	714	538	16.85	1,428		3	S_{20}	N_1	458	328	16.68	578	
1	1	S_{20}	N_1	468	313	16.70	586		1	S_{10}	N_1	624	344	16.27	1,277	28

SYSTEM OF REPLICATION : 6 randomised blocks of 9 plots each. Certain second order interactions partially confounded with block differences.

AREA OF EACH PLOT (after rejecting edge rows) : 10-inch spacing : 0.02083 acre ; 15-inch spacing : 0.01875 acre ; 20-inch spacing : 0.01667 acre. Plots actually 15.2 lks. × 164.5 lks. rows.

TREATMENTS : All combinations of :

$$\begin{array}{ccccc} \text{Sowing dates} & & \text{Spacing} & & \text{Sulph. amm.} \\ \left\{\begin{array}{ll} \text{March 15} & (1) \\ \text{April 18} & (2) \\ \text{May 16} & (3) \end{array}\right\} & \times & \left\{\begin{array}{ll} \text{10-inch} & (S_{10}) \\ \text{15-inch} & (S_{15}) \\ \text{20-inch} & (S_{20}) \end{array}\right\} & \times & \left\{\begin{array}{ll} \text{None } (-) & \\ \text{(0.3 cwt. N)} & (N_1) \\ \text{(0.6 cwt. N)} & (N_2) \end{array}\right\} \end{array}$$

BASAL MANURING : 10 tons dung per acre. Superphosphate at the rate of 0.5 cwt. P_2O_5 per acre and 30% potash manure salt at the rate of 1.0 cwt. K_2O per acre.

CULTIVATIONS, ETC. : Applied basal dressing of artificials : January 21. Ploughed : January 21-22. Harrowed and sulphate of ammonia applied to 1st sowing : March 14. Harrowed, rolled and drilled, 1st sowing : March 15. Rolled : March 16. Harrowed, 2nd sowing : April 13. Applied sulphate of ammonia to 2nd sowing : April 15. Harrowed : April 17. Harrowed, rolled and drilled, 2nd sowing : April 18. Harrowed, rolled, sulphate of ammonia applied and drilled, 3rd sowing : May 16. Harrowed and rolled : May 17. Hoed narrow and wide rows : May 18. Hoed narrow rows : May 23. Singled, 1st sowing : May 30. Singled, 2nd sowing : June 11-17. Hoed all wide rows : June 14. Singled, 3rd sowing : June 24-July 4. Hoed : July 8-19. Lifted : November 8-23. Variety : Kleinwanzleben E. Previous crop : Wheat.

STANDARD ERRORS PER PLOT : Roots (washed) : 0.873 tons per acre or 7.85%. Tops : 0.977 tons per acre or 11.5%. Sugar percentage : 0.288. Plant number : 2.45 thousands per acre or 5.01%. Mean dirt tare : 10 inch spacing : 0.122 ; 15 inch spacing : 0.116 ; 20 inch spacing : 0.101. There was a severe attack of Heart Rot. See p. 25.

Yields of Separate Treatments (block effects eliminated)

ROOTS (washed): tons per acre

Sowing date	Sulph. amm. per acre None			Sulph. amm. per acre 0.3 cwt. N.			Sulph. amm. per acre 0.6 cwt. N.		
	Spacing (inches)			Spacing (inches)			Spacing (inches)		
	10	15	20	10	15	20	10	15	20
March 15	9.75	10.42	10.74	11.37	11.91	11.52	13.01	12.71	12.49
April 18	10.22	9.69	10.48	10.08	9.63	12.36	13.39	11.02	13.06
May 16	9.35	8.43	11.46	10.83	10.61	10.93	11.37	11.51	10.94

Main effects. Interactions of sulphate of ammonia with spacing and sowing dates.

	Spacing (inches)			Sowing Dates			*Mean*	*Increase*
	10	15	20	Mar. 15	Apl. 18	May 16		
ROOTS (washed): tons per acre (±0.356. *Means : ±0.206. Increases : ±0.291*)								
0.0 cwt. N ..	9.77	9.51	10.89	10.30	10.13	9.75	*10.06*	
0.3 cwt. N ..	10.76	10.72	11.60	11.60	10.69	10.79	*11.03*	*+0.97*
0.6 cwt. N ..	12.59	11.75	12.16	12.74	12.49	11.27	*12.17*	*+1.14*
Mean	*11.04*	*10.66*	*11.55*	*11.55*	*11.10*	*10.60*	*11.08*	
Increase ..		*−0.38*	*+0.51*		*−0.45*	*−0.95*		
TOPS: tons per acre (±0.399. *Means : ±0.230. Increases : ±0.325*)								
0.0 cwt. N ..	7.08	6.55	7.27	6.29	6.90	7.72	*6.97*	
0.3 cwt. N ..	7.75	7.86	8.71	7.72	7.47	9.13	*8.11*	*+1.14*
0.6 cwt. N ..	10.94	10.13	9.76	9.25	9.99	11.59	*10.28*	*+2.17*
Mean	*8.59*	*8.18*	*8.58*	*7.75*	*8.12*	*9.48*	*8.45*	
Increase ..		*—0.41*	*—0.01*		*+0.37*	*+1.73*		
SUGAR PERCENTAGE (±0.118. *Means : ±0.0681. Increases : ±0.0963*)								
0.0 cwt. N ..	16.64	16.60	16.68	16.44	16.75	16.74	*16.64*	
0.3 cwt. N ..	16.50	16.68	16.56	16.65	16.52	16.56	*16.58*	*—0.06*
0.6 cwt. N ..	16.53	16.39	16.37	16.40	16.47	16.44	*16.44*	*—0.14*
Mean	*16.56*	*16.56*	*16.54*	*16.50*	*16.58*	*16.58*	*16.55*	
Increase ..		*0.00*	*—0.02*		*+0.08*	*+0.08*		
TOTAL SUGAR: cwt. per acre								
0.0 cwt. N ..	32.5	31.5	36.3	33.9	33.9	32.6	*33.5*	
0.3 cwt. N ..	35.5	35.8	38.4	38.6	35.3	35.7	*36.5*	*+3.0*
0.6 cwt. N ..	41.6	38.5	39.8	41.8	41.2	37.0	*40.0*	*+3.5*
Mean	*36.5*	*35.3*	*38.2*	*38.1*	*36.8*	*35.1*	*36.7*	
Increase ..		*−1.2*	*+1.7*		*−1.3*	*−3.0*		
PLANT NUMBER: thousands per acre (±1.00. *Means : ±0.577. Increases : ±0.816*)								
0.0 cwt. N ..	65.6	45.2	32.5	48.2	45.6	49.5	*47.8*	
0.3 cwt. N ..	65.8	43.9	32.5	47.5	45.9	48.7	*47.4*	*—0.4*
0.6 cwt. N ..	65.5	42.0	32.2	48.0	44.2	47.4	*46.5*	*—0.9*
Mean	*65.6*	*43.7*	*32.4*	*47.9*	*45.2*	*48.5*	*47.2*	
Increase ..		*—21.9*	*—33.2*		*—2.7*	*+0.6*		

Interaction of Spacing and Sowing Dates

Sowing Date	Spacing (inches) 10	15	20	Spacing (inches) 10	15	20
	ROOTS (washed) : tons per acre (±0.356)			TOPS : tons per acre (±0.399)		
March 15	11.38	11.68	11.58	7.88	7.88	7.49
April 18	11.23	10.11	11.97	8.27	7.51	8.58
May 16	10.52	10.18	11.11	9.61	9.15	9.67
	SUGAR PERCENTAGE : (±0.118)			TOTAL SUGAR : cwt. per acre		
March 15	16.59	16.50	16.38	37.7	38.6	38.0
April 18	16.63	16.44	16.67	37.3	33.3	39.8
May 16	16.45	16.72	16.55	34.6	34.0	36.8

Sowing Date	Spacing (inches) 10	15	20
	PLANT NUMBER : thousands per acre (±1.00)		
March 15 ..	66.4	44.2	33.2
April 18 ..	62.5	41.1	32.0
May 16 ..	67.8	45.8	32.0

Conclusions : Yields

Sulphate of ammonia significantly increased the yields of roots and tops and significantly decreased the sugar percentage, the net result being an increase in total sugar for the double dressing (0.6 cwt. N. per acre) of 6.5 cwt. per acre. The response in roots decreased as the width of spacing increased, the interaction between sulphate of ammonia and spacing being significant.

Apart from this and the effect on plant number, spacing produced no significant effect.

There was a significant reduction in roots and a significant increase in tops with the later sowing dates, but no effect on sugar percentage. Plant number was significantly lower at the second sowing than at the first or last.

Bolters : First sowing date

	Spacing (inches) 10	15	20	*Mean*	*Increase*
	PERCENTAGE OF BOLTERS				
0.0 cwt. N ..	10.07	12.96	15.86	*12.96*	
0.3 cwt. N ..	12.94	19.98	27.12	*20.01*	*+7.05*
0.6 cwt. N ..	21.58	21.41	23.89	*22.29*	*+2.28*
Mean	*14.86*	*18.12*	*22.29*	*18.42*	
Increase ..		*+3.26*	*+4.17*		

	Average sugar percentage	Average weight of root lb.
Bolters	16.15	0.476
Normal	16.49	0.613

Conclusions : Bolters

About 18 per cent. of the plants sown at the earliest date, March 15, bolted. There was practically no bolting with the later sowings.

The average weight of a bolter was about 20 per cent. smaller than that of a good root. The sugar percentage was also slightly smaller. Sulphate of ammonia increased the percentage of bolters. The percentage also increased as the width of spacing increased.

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SUGAR BEET

Effects of agricultural salt, applied before winter ploughing and at sowing, of dung, of additional heavy rolling of the seed-bed, and of normal and intensive inter-row cultivation

RS—Little Hoos, 1935

Plan and yields in lb.

		Roots (dirty)	Tops	Sugar per cent.	Plant number	Treatment	Roots (dirty)	Tops	Sugar per cent.	Plant number.	
78	— — — C	361	370	16.36	387	Na_2 D — C	535	436	16.91	530	102
	Na_1 D R —	588	444	16.83	571	Na_1 — — C	502	479	15.98	465	
	Na_2 D — C	507	368	17.62	567	Na_1 — R —	436	394	16.44	424	
	— D — —	519	404	17.26	601	— D — C	494	457	16.33	447	
	Na_2 — — —	498	350	16.82	517	— — R C	401	390	17.14	490	
	Na_2 D R —	526	354	17.51	563	— D R —	469	406	16.73	509	
	Na_2 — R C	526	374	17.35	525	Na_2 — — —	461	402	16.65	519	
	Na_1 — R C	519	334	17.48	527	Na_2 D R —	515	390	17.11	580	
	— D R C	584	418	17.48	576	Na_1 D R C	522	371	17.14	598	
	Na_1 — — —	557	356	17.52	527	Na_2 — R C	458	355	17.05	529	
	Na_1 D — C	632	426	17.26	583	— — — —	423	375	17.02	511	
	— — R —	522	443	16.84	529	Na_1 D — —	544	418	16.50	581	
	— — — —	531	471	17.34	508	Na_1 — — —	497	346	17.02	539	
	Na_2 — — C	594	444	17.18	529	Na_2 — — C	522	433	16.79	530	
	Na_1 D — —	635	417	17.48	607	Na_1 D — C	565	416	16.96	573	
	Na_2 — R —	556	330	16.96	466	— — R —	415	317	16.98	478	
	— D — C	627	384	17.18	591	Na_1 D R —	529	372	17.22	539	
	Na_1 D R C	599	386	17.46	556	— — — C	451	370	16.59	453	
	Na_1 — — C	534	332	17.70	520	Na_2 D R C	488	334	16.82	543	
	Na_1 — R —	539	326	17.12	486	— D R C	524	354	16.93	564	
	— — R C	526	376	17.34	455	Na_1 — R C	482	340	17.66	476	
	Na_2 D R C	591	378	17.72	529	Na_2 — R —	441	304	16.88	462	
	Na_2 D — —	555	318	17.40	566	— D — —	486	370	16.53	534	
55	— D R —	535	404	16.89	514	Na_2 D — —	498	365	17.57	534	79

E ↑

SYSTEM OF REPLICATION : 4 randomised blocks of 12 plots each. Certain high order interactions are partially confounded with block differences.

AREA OF EACH PLOT (after rejecting edge rows) : 1/56 acre. Plots actually 1/40 acre (17.7 lks· x 141.2 lks.).

TREATMENTS : All combinations of :

(*a*) No salt (—), agricultural salt at the rate of 4 cwt. NaCl per acre applied before ploughing in winter (Na_1), and agricultural salt applied before sowing (Na_2).
(*b*) No dung (—), and dung at the rate of 10 tons per acre applied before winter ploughing (D).
(*c*) Ordinary rolling of seed-bed (—), and ordinary rolling + additional heavy rolling (R).
(*d*) Normal (—), and normal + intensive inter-row cultivation with motor hoe at 10-daily intervals (C).

BASAL MANURING: 0.6 cwt. N per acre as sulphate of ammonia, applied at seeding, 1.0 cwt. K_2O per acre as muriate of potash (high grade), and 0.5 cwt. P_2O_5 per acre as superphosphate applied before ploughing in winter.

CULTIVATIONS, ETC. : Applied dung : Jan. 18 and 22. Applied winter artificials : Jan. 22. Ploughed : Jan. 23-26. Cultivated : April 18. Rolled, harrowed and applied artificials : April 29. Seed sown : April 29. Rolled (heavy roll plots) : May 9. Horse hoed : June 14. Singled : June 14-17. Motor hoed "Intensive" plots : June 29, July 10 and 22. Motor cultivated "Intensive" plots : July 30 and Aug. 9. Hand hoed : July 9 and 10. Horse hoed : July 18th. Lifted : Nov. 25-29. Variety : Kleinwanzleben E. Previous crop : Wheat.

STANDARD ERRORS PER PLOT : (Roots washed) : 0.692 tons per acre or 5.98%. Tops : 0.936 tons per acre or 9.77%. Sugar percentage : 0.296. Plant number : 1.78 thousands per acre or 6.06%. Mean dirt tare : 0.1048

Responses to Treatments

MEAN YIELDS: Roots (washed): *11.57* tons; Tops: *9.58* tons; Sugar percentage: *17.06*; Total sugar: *39.5* cwt.; Plant number: *29.4* thousands.

	Mean response	Salt Absent	Salt Present	Dung Absent	Dung Present	Rolling Ordinary	Rolling Additional	Cultivation Ordinary	Cultivation Intensive
	ROOTS (washed): tons per acre								
Salt	*+0.85*^{1}	—	—	+1.20^{2}	+0.49^{2}	+1.19^{2}	+0.50^{2}	+0.82^{2}	+0.90^{2}
Dung	*+1.23*^{5}	+1.70^{3}	+1.00^{4}	—	—	+1.25^{6}	+1.22^{6}	+0.99^{6}	+1.48^{6}
Rolling	*−0.22*^{5}	+0.24^{3}	−0.45^{4}	−0.20^{6}	−0.24^{6}	—	—	−0.24^{6}	−0.20^{6}
Intensive cultivation ..	*+0.25*^{5}	+0.20^{3}	+0.28^{4}	+0.01^{6}	+0.50^{6}	+0.23^{6}	+0.28^{6}	—	—
St. errors ..	(1) ±0.212, (2) ±0.300, (3) ±0.346, (4) ±0.245, (5) ±0.199, (6) ±0.282.								
	TOPS: tons per acre								
Salt	*−0.41*^{1}	—	—	−0.51^{2}	−0.31^{2}	−0.15^{2}	−0.67^{2}	−0.77^{2}	−0.05^{2}
Dung	*+0.39*^{5}	+0.26^{3}	+0.46^{4}	—	—	+0.10^{6}	+0.68^{6}	+0.52^{6}	+0.27^{6}
Rolling	*−0.64*^{5}	−0.29^{3}	−0.82^{4}	−0.93^{6}	−0.35^{6}	—	—	−0.23^{6}	−1.05^{6}
Intensive cultivation ..	*+0.26*^{5}	−0.22^{3}	+0.50^{4}	+0.38^{6}	+0.14^{6}	+0.67^{6}	−0.15^{6}	—	—
St. errors ..	(1) ±0.287, (2) ±0.406, (3) ±0.468, (4) ±0.331, (5) ±0.270, (6) ±0.382.								
	SUGAR PERCENTAGE								
Salt	*+0.19*^{1}	—	—	+0.09^{2}	+0.30^{2}	+0.25^{2}	+0.13^{2}	+0.11^{2}	+0.27^{2}
Dung	*+0.11*^{5}	−0.04^{3}	+0.18^{4}	—	—	+0.17^{6}	+0.05^{6}	+0.12^{6}	+0.10^{6}
Rolling	*+0.13*^{5}	+0.21^{3}	+0.09^{4}	+0.19^{6}	+0.07^{6}	—	—	−0.14^{6}	+0.39^{6}
Intensive cultivation ..	*+0.07*^{5}	−0.03^{3}	+0.13^{4}	+0.08^{6}	+0.06^{6}	−0.19^{6}	+0.34^{6}	—	—
St. errors ..	(1) ±0.0909, (2) ±0.128, (3) ±0.148, (4) ±0.105, (5) ±0.0857, (6) ±0.121								
	TOTAL SUGAR: cwt. per acre								
Salt	*+3.3*	—	—	+4.2	+2.4	+4.7	+2.0	+3.0	+3.6
Dung	*+4.4*	+5.6	+3.8	—	—	+4.6	+4.3	+3.6	+5.2
Rolling	*−0.4*	+1.3	−1.3	−0.3	−0.6	—	—	−1.1	+0.2
Intensive cultivation ..	*+1.0*	+0.6	+1.2	+0.2	+1.8	+0.4	+1.7	—	—
	PLANT NUMBER: thousands per acre								
Salt	*+1.3*^{1}	—	—	+1.4^{2}	+1.2^{2}	+2.2^{2}	+0.5^{2}	+0.4^{2}	+2.2^{2}
Dung	*+3.5*^{5}	+3.7^{3}	+3.4^{4}	—	—	+3.4^{6}	+3.7^{6}	+3.4^{6}	+3.6^{6}
Rolling	*−0.5*^{5}	+0.6^{3}	−1.1^{4}	−0.7^{6}	−0.4^{6}	—	—	−2.0^{6}	+0.9^{6}
Intensive cultivation ..	*−0.3*^{5}	−1.5^{3}	+0.3^{4}	−0.4^{6}	−0.2^{6}	−1.7^{6}	+1.2^{6}	—	—
St. errors ..	(1) ±0.546, (2) ±0.772, (3) ±0.891, (4) ±0.629, (5) ±0.514, (6) ±0.727.								

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Main effects and interactions of salt

Salt	No Dung	Dung	Ordinary rolling	Heavy rolling	Normal cultiva-tion	Intensive cultiva-tion	*Mean*	*Increase*
ROOTS (washed): tons per acre (±0.245. *Means : ±0.173. Increases : ±0.245*)								
None	10.16	11.86	10.89	11.12	10.91	11.10	*11.01*	
Before ploughing	11.37	12.91	12.49	11.79	12.10	12.18	*12.14*	*+1.13*
Before sowing	11.34	11.79	11.66	11.47	11.33	11.81	*11.57*	*+0.56*
TOPS: tons per acre (±0.331. *Means : ±0.234. Increases : ±0.331*)								
None ..	9.73	9.99	10.00	9.71	9.97	9.75	*9.86*	
Before ploughing	9.08	10.16	9.97	9.27	9.60	9.64	*9.62*	*−0.24*
Before sowing	9.35	9.20	9.74	8.81	8.79	9.76	*9.28*	*−0.58*
SUGAR PERCENTAGE: (±0.105. *Means : ±0.0742. Increases: ±0.105*)								
None	16.95	16.92	16.83	17.04	16.95	16.92	*16.94*	
Before ploughing	17.12	17.10	17.05	17.17	17.02	17.20	*17.11*	*+0.17*
Before sowing	16.96	17.33	17.12	17.18	17.11	17.18	*17.15*	*+0.21*
TOTAL SUGAR: cwt. per acre								
None	34.4	40.1	36.6	37.9	37.0	37.6	*37.3*	
Before ploughing	38.9	44.2	42.6	40.5	41.2	41.9	*41.6*	*+4.3*
Before sowing	38.5	40.9	39.9	39.4	38.8	40.6	*39.7*	*+2.4*
PLANT NUMBER: thousands per acre (±0.629. *Means : ±0.445. Increases : ±0.629*)								
None ..	26.7	30.4	28.2	28.8	29.3	27.8	*28.5*	
Before ploughing	27.8	32.3	30.8	29.2	29.9	30.1	*30.0*	*+1.5*
Before sowing	28.5	30.9	30.0	29.4	29.4	30.0	*29.7*	*+1.2*

Conclusions

Salt produced significant increases in the yield of roots and the sugar percentage, and a small but not significant decrease in the yield of tops. The increase in total sugar was 3.3 cwt. per acre. The increase in roots was significantly greater when the salt was applied before winter ploughing than when it was applied at sowing. This effect, however, appeared only in presence of dung, the interaction between dung and time of application of salt being significant. Otherwise there was little difference in the effects of time of application.

Dung significantly increased the yield of roots, the resultant increase in total sugar being 4.4 cwt. per acre. The increases in tops and sugar percentage were not significant.

Additional heavy rolling gave a significant decrease in tops. There were no significant differences between the effects of ordinary and intensive inter-row cultivation.

Plant number was significantly increased by salt and dung.

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SUGAR BEET

Soil fumigation experiment. Effect of chlorpicrin, chlordinitrobenzene, "seekay" and "cymag," as controls of wireworm infestation.

RS—PASTURES, 1935

Plan and yields in lb.

Roots (dirty), tops, sugar percentage and plant number in descending order

103	P 217 298 15.72 439	O 284 330 15.92 442	N 359 440 15.38 474	K 148 178 14.83 424	M 488 532 16.01 512	107
108	M 466 494 15.49 514	K 146 152 15.69 440	O 434 402 16.47 520	N 431 448 16.27 504	P 450 439 16.48 507	
S ↑	O 460 434 16.13 511	M 522 522 16.93 515	K 165 202 15.26 464	P 555 378 16.53 523	N 516 546 15.95 495	
	N 476 486 16.01 500	P 464 418 16.30 498	M 546 542 16.39 476	O 500 476 16.13 464	K 179 196 15.20 439	
123	K 188 213 15.06 426	N 386 426 15.87 444	P 384 375 15.78 479	M 458 461 16.36 486	O 344 306 16.21 451	127

Note : In the field the plots lay in one line, 108 being next to 107, etc.

System of Replication : 5 × 5 Latin square.

Area of Each Plot : 1/60 acre (60.6 lks. × 27.5 lks.).

Treatments : No fumigant (O), chlordinitrobenzene (N) and chlorpicrin (P) at the rate of 2.0 cwt. per acre, "cymag" (M) at the rate of 7.5 cwt. per acre and "seekay" (K) at the rate of 5.0 cwt. per acre.

Basal Manuring : 4 cwt. superphosphate, 2 cwt. muriate of potash and 1 cwt. sulphate of ammonia per acre.

Cultivations, etc. : Ploughed : April 26. Fumigants applied as ploughed. Harrowed : April 30. Rolled : April 30. Seed sown : April 30. Harrowed: May 2. Rolled : May 2. Singled : June 15. Hoed : June 18, 29, July 25 and 26. Lifted : November 5-8. Variety : Klein-wanzleben. Previous crop : Grass.

Standard Errors per Plot : Roots (washed) : 0.953 tons per acre or 9.91%. Tops : 1.08 tons per acre or 9.22% Sugar percentage : 0.290. Plant number : 1.18 thousands per acre or 4.11%. The "Seekay" treatment was omitted in the analysis of roots and tops, owing to its low yields. Mean dirt tare : 0.1785.

Summary of Results

	No fumigant	Chlordini-troben-zene	Chlor-picrin	'Cymag'	'Seekay'	*Mean*	Standard Error
ROOTS (washed), tons per acre	8.90	9.54	9.11	10.91	3.64	*8.42*	±0.426*
TOPS, tons per acre ..	10.44	12.57	10.22	13.67	5.04	*10.39*	±0.519*
SUGAR PERCENTAGE ..	16.16	15.92	16.16	16.24	15.22	*15.94*	±0.130
TOTAL SUGAR, cwt. per acre	28.8	30.4	29.4	35.4	11.1	*27.0*	—
PLANT NUMBER, thousands per acre	28.6	29.0	29.4	30.0	26.3	*28.7*	±0.528

* These standard errors are not applicable to the " Seekay " treatment.

Conclusions : Yields

The yield of roots with "cymag" was significantly higher than that with chlorpicrin or chlordinitrobenzene, the latter yields not being significantly different from the yield with no fumigant. The response to " cymag " may be an effect of nitrogen, the dressing being equivalent to 87 lb. nitrogen per acre.

" Cymag " and chlordinitrobenzene significantly increased the yields of tops, the increases not being significantly different. There were no significant effects on sugar percentage, apart from the reduction due to " seekay."

" Seekay " gave low yields and a low sugar percentage. This was possibly because it was applied too near sowing date.

No relation was found between the yields of roots and the numbers of wireworms at the second count, after eliminating treatment effects.

Wireworm Counts :

Plan and number of wireworms per plot (total of six samples)
1st count above, 2nd count below

103	P 6 6	O 6 3	N 20 29	K 34 8	M 19 17	107
	M 15 8	K 20 13	O 34 18	N 25 12	P 26 16	
S ↑	O 20 16	M 17 12	K 24 7	P 33 10	N 22 28	
	N 39 14	P 24 11	M 36 13	O 24 22	K 32 7	
123	K 26 7	N 22 26	P 35 24	M 29 14	O 19 20	127

Note: At the first count three random samples per half plot were taken; at the second count two per third of a plot. Each sample consisted of 9 ins. × 9 ins. × 4 ins. (deep) of soil.

STANDARD ERRORS PER PLOT : First count : sampling error : 6.06 or 25% ; experimental error : 6.99 or 29%. Second count : sampling error : 4.87 or 34% ; experimental error : 7.18 or 50%.

Summary of Results : Second Count

No. of wireworms per square yard, 4 inches deep

No fumigant	Chlordini-trobenzene	Chlor-picrin	"Cymag"	"Seekay"	*Mean*	Standard error.
42	58	36	34	22	*38*	±8.59

Conclusions : Wireworm Counts

The effects of the treatments on the numbers of wireworms were not significant. No relation was found between the numbers of wireworms per plot at the first and second counts, after allowing for possible treatment effects.

BRUSSELS SPROUTS

Effect of sulphate of ammonia, poultry manure, soot and rape dust

FOSTER'S—RD, 1935

Plan and yields in lb. saleable sprouts

Total of both Pickings

SW ↑

1								8
	R_1 37.0	N_2 22.5	M_2 13.5	M_1 26.5	M_0 34.5	R_1 29.0	R_0 37.5	N_1 32.5
	S_2 41.0	S_1 25.0	N_1 12.0	M_0 17.5	S_0 21.5	M_1 34.0	M_2 41.0	N_2 35.0
	R_0 27.5	S_0 15.5	R_2 25.0	N_0 17.0	R_2 41.0	S_2 36.5	N_0 44.5	S_1 26.0
	R_0 26.0	N_2 15.5	M_1 17.0	S_1 30.0	R_0 21.5	R_2 27.0	R_1 25.5	M_1 30.0
	N_0 17.0	M_2 20.0	M_0 23.5	S_0 19.5	M_0 23.5	N_2 28.0	N_1 30.0	S_2 30.5
41	R_1 19.5	S_2 25.5	R_2 20.0	N_1 29.5	S_0 28.0	N_0 20.5	S_1 24.5	M_2 24.4* 48

* Estimated.

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

AREA OF EACH PLOT (after rejecting edge rows) : 0.024174 acre. Plots actually 10 yds. × 14 yds.

TREATMENTS : 1935. No nitrogen (O), sulphate of ammonia (N) half applied in seed bed and remainder as a top dressing, poultry manure (M), soot (S) and rape dust (R), applied at the rate of 0.4 cwt. N per acre (1) or 0.8 cwt. N per acre (2).
Plots receiving treatment O in 1935 had treatment 2 in 1934 and vice versa. Plots receiving treatment 1 had this in both years. For N_0, S_0, M_0 and R_0 (see plan), the treatment symbols refer to the 1934 treatment.

BASAL MANURING : All plots were made up to 1.0 cwt. P_2O_5 per acre. and 1.0 cwt. K_2O per acre, using superphosphate and muriate of potash (an allowance being made for the P_2O_5 and K_2O contained in the organic manures).

CULTIVATIONS, ETC. : Ploughed : Mar. 5 and 6. Harrowed : Mar. 16. Ploughed : Mar. 18-20. Harrowed : May 3. Rolled : May 3. Manures applied : May 22-29. Second half of sulphate of ammonia applied : July 27. Harrowed : May 28-29. Rolled : May 30. Brussels planted : June 5-6. Hoed : July 24, 30, 31 and Sept. 16. Harvested : First picking : Nov. 19-20. Second picking : Mar. 5. Previous crop : Brussels.

STANDARD ERROR PER PLOT (total of both pickings, saleable sprouts): 2.42 cwt. per acre or 24.8%.

SPECIAL NOTE : Owing to damage by pigeons the weights at the second picking were very small.

Saleable Sprouts—total of both pickings : cwt. per acre (±1.21)

Nitrogen, cwt. p.a. 1934	1935	Sulph. amm.	Poultry manure.	Soot.	Rape dust.	*Mean.* (±*0.605*)
0.8	0.0	9.1	9.1	7.8	10.4	*9.1*
0.4	0.4	9.6	9.9	9.7	10.2	*9.8*
0.0	0.8	9.3	9.1	12.3	10.4	*10.3*
Mean (±*0.699*)		*9.3*	*9.4*	*9.9*	*10.3*	*9.7*

Conclusions

The experiment is designed to measure the difference in the immediate and cumulative effects of certain organic fertilisers and sulphate of ammonia. The yield was a very poor one, owing to adverse weather conditions and damage by birds. There were no significant effects.

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BEANS

Effect of dung, nitrochalk, superphosphate and muriate of potash, and of spacing of the rows.

RE—Little Hoos, 1935.

Plan and yields in lb., grain above, straw below.

1	S_1NK 71.2 86.8	S_1 66.5 82.5	S_1P 56.7 68.3	S_1NPK 48.0 52.0	4
	S_2NP 45.7 57.3	S_2DN 70.5 93.0	S_2DNP 64.6 82.4	S_2N 23.3 25.7	
W ↑	S_1DP 76.7 95.3	S_2PK 74.3 84.7	S_1D 74.8 97.2	S_2K 39.3 41.2	
	S_2DK 73.3 86.7	S_1DNPK 77.0 112.5	S_1DNK 73.7 104.3	S_2DPK 56.3 71.7	
	S_2 36.2 40.3	S_2DP 49.8 65.2	S_1N 68.0 81.5	S_1K 63.6 68.9	
	S_2NK 60.5 62.5	S_1DK 51.3 73.2	S_2DNK 92.5 114.5	S_1DPK 63.6 82.9	
	S_1NP 36.3 48.7	S_2DNPK 61.3 82.2	S_2P 29.9 39.1	S_1DNP 60.8 80.7	
29	S_1DN 67.3 88.2	S_1PK 49.6 57.9	S_2D 54.7 69.3	S_2NPK 47.9 60.1	32

System of Replication: 4 randomised blocks of 8 plots each. Certain interactions confounded with block differences. Error estimated from high order interactions.

Area of Each Plot: 1/40 acre (68.7 lks. × 36. 4 lks.)

Treatments: All combinations of :

$$\underset{\text{Spacing}}{\left\{\begin{array}{l}\text{18 ins. } (S_1)\\ \text{24 ins. } (S_2)\end{array}\right\}} \times \underset{\text{Dung}}{\left\{\begin{array}{l}\text{None}\\ \text{10 tons (D)}\end{array}\right\}} \times \underset{\text{Nitro-chalk}}{\left\{\begin{array}{l}\text{None}\\ \text{0.4 cwt.N (N)}\end{array}\right\}} \times \underset{\text{Superphosphate}}{\left\{\begin{array}{l}\text{None}\\ \text{0. 6 cwt. } P_2O_5 \text{ (P)}\end{array}\right\}}$$

$$\times \underset{\text{Muriate of Potash}}{\left\{\begin{array}{l}\text{None}\\ \text{1.0 cwt. } K_2O \text{ (K)}\end{array}\right\}}$$

Cultivations: Dung applied: Oct. 10. Ploughed: Oct. 10-17. Artificials applied: Oct. 20. Harrowed: Oct. 22. Drilled: Oct. 22. Harrowed: Oct. 24 and Mar. 20. Nitro-chalk applied: Mar. 28. Hand hoed: May 1-7. Harvested: Aug. 6. Previous crop: Wheat.

Standard Errors per Plot: Grain: 3.38 cwt. per acre or 16.1%. Straw: 3.57 cwt. per acre or 13.6%.

Responses to fertilisers : cwt. per acre.

Mean yields : Grain : 21·0 cwt. ; Straw : 26·3 cwt.

Treatment	*Mean response*	Differential responses									
		Spacing		Dung		Nitro-chalk		Super-phosphate		Muriate of Potash	
		18 ins.	24 ins.	Abs.	Pres.	Abs.	Pres.	Abs.	Pres.	Abs.	Pres.
GRAIN : ($\pm$1.69. *Mean response* : $\pm$1.20)											
Spacing 18 ins. —24 ins.	*+2.8*	—	—	+4.6	+1.0	+4.0	+1.6	+3.8	+1.7	+5.9	−0.3
Dung ..	*+5.6*	+3.8	+7.4	—	—	+3.8	+7.4	+5.8	+5.4	+7.0	+4.2
Nitro-chalk ..	*+1.2*	0.0	+2.4	−0.7	+3.0	—	—	+3.0	−0.7	−0.4	+2.7
Super-phosphate	*−2.0*	−3.0	−0.9	−1.8	−2.1	−0.1	−3.8	—	—	−1.8	−2.1
Muriate of potash ..	*+2.7*	−0.4	+5.8	+4.1	+1.3	+1.2	+4.2	+2.8	+2.6	—	—
STRAW : ($\pm$1.78. *Mean response* : $\pm$1.26)											
Spacing 18 ins. —24 ins.	*+4.6*	—	—	+6.1	+3.1	+5.7	+3.4	+6.6	+2.5	+7.6	+1.6
Dung ..	*+9.8*	+8.4	+11.3	—	—	+7.1	+12.6	+10.6	+9.1	+10.2	+9.5
Nitro-chalk ..	*+2.4*	+1.3	+3.5	−0.4	+5.2	—	—	+4.3	+0.5	0.0	+4.8
Super-phosphate	*−1.7*	−3.8	+0.4	−0.9	−2.4	+0.2	−3.6	—	—	−1.8	−1.5
Muriate of potash ..	*+2.8*	−0.2	+5.8	+3.1	+2.5	+0.4	+5.2	+2.7	+3.0	—	—

Interaction of spacing and muriate of potash.

Spacing	GRAIN : cwt. per acre Muriate of potash		STRAW : cwt. per acre Muriate of potash	
	None	1.0 cwt. K_2O	None	1.0 cwt. K_2O
18 inches ..	22.6	22.2	28.7	28.5
24 inches ..	16.7	22.6	21.1	26.9

STANDARD ERRORS : Grain : $\pm$1.20. Straw : $\pm$1.26.

Conclusions

The 18-inch spacing gave significantly higher yields of both grain and straw than the 24-inch spacing. The responses to dung were both significant, that for grain being 5.6 cwt. per acre or 26.7 per cent. of the mean yield. The increases due to nitro-chalk were not significant. Superphosphate produced slight, though not significant, decreases in yield. The response to muriate of potash was significant in the case of grain and almost significant in the case of straw. This effect, however, appeared only with the 24-inch spacing, the interaction between muriate of potash and spacing being significant for both grain and straw.

N

WHEAT

WOBURN

Effect of sulphate of ammonia applied at five different times

WW—Butt Close, 1935

Yield in lb., grain above, straw below

1	**5** 29.8 39.5	**2** 26.9 57.5	**3** 19.5 58.3	**1** 26.7 51.6	**0** 22.2 29.7	**4** 24.6 48.0	6
	0 30.8 29.8	**4** 34.7 46.2	**5** 33.5 36.5	**3** 27.8 57.9	**1** 32.6 53.7	**2** 32.1 45.8	
W ↑	**2** 37.0 51.0	**1** 34.2 47.0	**4** 39.6 48.1	**5** 39.0 45.8	**3** 33.3 58.0	**0** 26.2 33.1	
	1 34.0 49.4	**5** 37.5 42.3	**0** 27.0 33.6	**2** 39.2 59.4	**4** 39.6 53.4	**3** 28.5 45.9	
	4 39.6 50.3	**3** 35.5 52.3	**2** 42.8 50.2	**0** 34.2 45.0	**5** 43.7 48.9	**1** 37.0 50.0	
31	**3** 37.0 50.8	**0** 29.9 38.0	**1** 38.5 55.0	**4** 41.4 55.3	**2** 39.6 63.3	**5** 36.1 39.5	36

SYSTEM OF REPLICATION : 6×6 Latin square.
AREA OF EACH PLOT : 1/100 acre (40 lks. × 25 lks.).
TREATMENTS : No sulphate of ammonia (**0**) and sulphate of ammonia at the rate of 0.4 cwt. N per acre, applied on Dec. 7 (**1**), Jan. 31 (**2**), Mar. 28 (**3**), May 9 (**4**) and June 6 (**5**).
CULTIVATIONS, ETC. : Ploughed : Oct. 31. Harrowed : Nov. 3, 7 and 8. Drilled : Nov. 8. Harvested : Aug. 2. Plots harvested by weighing total produce and sampling for grain-straw ratio. Variety : Victor. Previous crop : Potatoes.
STANDARD ERRORS PER PLOT : Grain : 1.59 cwt. per acre or 5.31% ; straw : 3.27 cwt. per acre or 7.66%.

Summary of results, cwt. per acre

	No N	Dates of application of sulphate of ammonia (0.4 cwt. N per acre) Dec. 7	Jan. 31	Mar. 28	May 9	June 6	*Mean of all N*	*St. error*
GRAIN (±0.649)	25.3	30.2	32.4	27.0	32.7	32.7	*31.0*	*±0.290*
Incr. (*±0.918*)		*+4.9*	*+7.1*	*+1.7*	*+7.4*	*+7.4*	*+5.7*	*±0.711*
STRAW ±1.34	31.1	45.6	48.7	48.1	44.8	37.6	*45.0*	*±0.597*
Incr. (*±1.89*)		*+14.5*	*+17.6*	*+17.0*	*+13.7*	*+6.5*	*+13.9*	*±1.46*

Conclusions

There was a significant average response to sulphate of ammonia of 5.7 cwt. of grain and 13.9 cwt. of straw per acre. There were also significant differences in yield due to time of application, the grain yields varying irregularly while the straw yields increased to a maximum and then decreased, the parabolic regression of yield on time of application being significant for straw.

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SUGAR BEET

WOBURN

Effect of sowing date, spacing of rows and of sulphate of ammonia.

WS—BUTT CLOSE, 1935

Plan and yields in lb.

	Plot	Roots (dirty)	Tops	Sugar per cent.	Plant number		Plot	Roots (dirty)	Tops	Sugar per cent.	Plant number	
54	3 S_{15} N_2	887	852	15.95	854		3 S_{20} —	473	357	16.96	537	27
	2 S_{15} N_1	902	735	16.39	896		2 S_{10} —	692	479	16.76	1,546	
	2 S_{10} —	1,021	724	16.13	1,642		1 S_{10} N_1	742	495	16.36	1,500	
	3 S_{20} —	592	492	15.64	610		3 S_{15} N_1	635	460	15.98	727	
	2 S_{20} N_2	757	778	14.80	600		3 S_{10} N_2	653	504	16.04	1,294	
	1 S_{15} —	861	846	14.14	846		2 S_{20} N_1	545	385	15.58	574	
	3 S_{10} N_1	957	1,094	15.64	1,353		1 S_{15} —	596	437	16.27	802	
	1 S_{20} N_1	810	742	15.20	555		2 S_{15} N_2	643	512	14.97	783	
	1 S_{10} N_2	1,023	1,105	14.89	1,524		1 S_{20} N_2	511	440	15.81	488	
	1 S_{15} N_1	907	859	15.61	867		1 S_{10} N_2	693	528	15.92	1,285	
	1 S_{10} —	921	878	15.94	1,438		2 S_{20} N_2	518	476	15.20	531	
	3 S_{10} N_2	964	905	15.84	1,481		1 S_{20} —	445	328	15.30	558	
	2 S_{10} N_1	1,061	1,011	15.40	1,539	W ↑	2 S_{15} —	612	384	16.59	876	
	2 S_{15} N_2	966	1,018	15.03	773		1 S_{15} N_1	704	489	15.88	753	
	3 S_{20} N_1	750	639	16.53	537		3 S_{15} N_2	760	547	16.47	764	
	3 S_{15} —	815	660	16.42	880		3 S_{20} N_1	641	398	16.56	511	
	2 S_{20} —	721	543	16.56	591		3 S_{10} —	764	433	16.65	1,406	
	1 S_{20} N_2	833	676	16.24	546		2 S_{10} N_1	956	609	15.64	1,498	
	1 S_{15} N_2	868	715	15.55	861		2 S_{20} —	609	409	15.98	552	
	3 S_{15} N_1	671	554	16.44	802		3 S_{20} N_2	580	480	16.50	503	
	2 S_{10} N_2	849	766	15.61	1,462		1 S_{10} —	781	429	16.53	1,386	
	2 S_{20} N_1	559	461	15.98	518		2 S_{10} N_2	837	617	16.53	1,350	
	3 S_{10} —	722	533	16.59	1,380		1 S_{20} N_1	567	393	15.84	483	
	1 S_{10} N_1	837	485	16.30	1,330		2 S_{15} N_1	642	465	15.75	729	
	2 S_{15} —	669	497	15.61	872		1 S_{15} N_2	661	580	15.61	639	
	3 S_{20} N_2	555	513	15.46	504		3 S_{15} —	598	436	16.70	740	
28	1 S_{20} —	558	398	15.81	547		3 S_{10} N_1	571	504	15.58	1,249	1

SYSTEM OF REPLICATION : 6 randomised blocks of 9 plots each. Certain second order interactions are partially confounded with block differences.

AREA OF EACH PLOT (after rejecting edge-rows) : 10 inch spacing : 0.02381 acre ; 15 inch spacing : 0.02143 acre ; 20 inch spacing : 0.01905 acre. Plots actually : 15.2 links × 188 links rows.

TREATMENTS : All combinations of :

Sowing dates		Spacing		Sulph. Amm.
April 18 (1)	×	10 inch (S_{10})	×	None (—)
May 9 (2)		15 inch (S_{15})		(0.3 cwt. N) (N_1)
May 25 (3)		20 inch (S_{20})		(0.6 cwt. N) (N_2)

Sulphate of ammonia to be applied at time of sowing (see special note).

BASAL MANURING : Superphosphate at the rate of 0.5 cwt. P_2O_5 per acre. 30% potash manure salt at the rate of 1.0 cwt. K_2O per acre. (Applied before winter ploughing.)

CULTIVATIONS, ETC. : Basal manures applied : January 4-11. Ploughed : January 4-11. Tractor-cultivated and harrowed : March 8-11. Harrowed and rolled first sowing : April 18. Harrowed and rolled second sowing : May 9. Cut out thistles first and second sowings : May 19-20. Spring-tine harrowed : May 25. Hand-hoed 10.-in. rows on first sowing : May 29. Horse-hoed 15 and 20-in. rows on first and second sowing : May 30. Singled first sowing : June 5-11. Hoed 10-in. rows on second sowing : June 9-12. Singled second sowing : June 11-14. Horse and hand-hoed : June 19-20. Singled third sowing : June 24-26. Hand-hoed : July 8-22. Lifted : November 7-16. Variety : Kleinwanzleben E. Previous crop : Potatoes.

SPECIAL NOTE : The first sowing was originally made on March 14, but this failed and was replaced by the sowing on May 25. The sulphate of ammonia for this sowing was applied on March 14.

STANDARD ERRORS PER PLOT : Roots (washed) : 1.06 tons per acre or 8.37%. Tops : 1.78 tons per acre or 14.2%. Sugar percentage : 0.459. Plant number : 2.63 thousands per acre, or 6.05%. Mean dirt tare : 0.1714.

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Yields of Separate Treatments (block effects eliminated)
ROOTS (washed), tons per acre

Sowing Date	Sulph. amm. per acre None			Sulph. amm. per acre. 0.3 cwt. N.			Sulph. amm. per acre. 0.6 cwt. N.		
	Spacing (inches)			Spacing (inches)			Spacing (inches)		
	10	15	20	10	15	20	10	15	20
April 18	13.18	12.28	10.81	13.97	13.35	13.39	13.07	15.05	13.24
May 9	12.11	11.91	11.93	14.85	12.89	12.18	14.52	13.40	12.14
May 25	11.71	11.92	9.52	11.04	12.28	12.30	11.20	13.78	12.34

Main effects : Interaction of sulphate of ammonia with spacing and sowing dates

	Spacing (inches)			Sowing date			*Mean*	*Increase*
	10	15	20	April 18	May 9	May 25		
ROOTS (washed) : tons per acre (±0.433. *Means: ±0.250. Increases: ±0.354.*)								
0.0 cwt. N ..	12.33	12.04	10.75	12.09	11.98	11.05	*11.71*	
0.3 cwt. N ..	13.29	12.84	12.62	13.57	13.31	11.87	*12.92*	*+1.21*
0.6 cwt. N ..	12.93	14.08	12.57	13.79	13.35	12.44	*13.19*	*+0.27*
Mean	*12.85*	*12.99*	*11.98*	*13.15*	*12.88*	*11.79*	*12.61*	
Increase ..		*+0.14*	*−0.87*		*−0.27*	*−1.36*		
TOPS : tons per acre (±0.727. *Means:* ±0.420. *Increases:* ±0.594.)								
0.0 cwt. N ..	10.86	11.32	9.87	11.37	10.54	10.14	*10.69*	
0.3 cwt. N ..	13.12	12.37	11.79	12.18	12.53	12.56	*12.42*	*+1.73*
0.6 cwt. N ..	13.83	14.67	13.14	13.96	14.53	13.14	*13.88*	*+1.46*
Mean ..	*12.60*	*12.79*	*11.60*	*12.50*	*12.53*	*11.95*	*12.33*	
Increase ..		*+0.19*	*−1.00*		*+0.03*	*−0.55*		
SUGAR PERCENTAGE (±0.187. *Means:* ±0.108. *Increases:* ±0.153.)								
0.0 cwt. N ..	16.43	15.96	16,04	15.67	16.27	16.49	*16.14*	
0.3 cwt. N ..	15.82	16.00	15.95	15.86	15.79	16.12	*15.92*	*−0.22*
0.6 cwt. N ..	15.80	15.60	15.67	15.67	15.36	16.04	*15.69*	*−0.23*
Mean	*16.02*	*15.85*	*15.89*	*15.73*	*15.81*	*16.22*	*15.92*	
Increase ..		*−0.17*	*−0.13*		*+0.08*	*+0.49*		
TOTAL SUGAR : cwt. per acre (±1.49. *Means : ±0.860. Increases : ±1.22*)								
0.0 cwt. N ..	40.4	38.1	34.6	38.1	38.8	36.5	*37.8*	
0.3 cwt. N ..	42.0	41.1	40.2	42.8	42.2	38.1	*41.0*	*+3.2*
0.6 cwt. N ..	40.7	43.9	39.4	42.9	40.9	40.0	*41.3*	*+0.3*
Mean	*41.1*	*41.0*	*38.0*	*41.3*	*40.7*	*38.2*	*40.0*	
Increase ..		*−0.1*	*−3.1*		*−0.6*	*−3.1*		
PLANT NUMBER : thousands per acre (±1.07. *Means:* ±0.618. *Increases:* ±0.874).								
0.0 cwt. N ..	61.6	39.0	29.7	42.2	45.9	42.1	*43.4*	
0.3 cwt. N ..	59.3	37.1	27.8	41.5	43.5	39.3	*41.4*	*−2.0*
0.6 cwt. N ..	58.8	36.4	27.8	40.4	41.7	40.8	*41.0*	*−0.4*
Mean	*59.9*	*37.5*	*28.4*	*41.4*	*43.7*	*40.7*	*41.9*	
Increase ..		*−22.4*	*−31.5*		*+2.3*	*−0.7*		

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Interaction of spacing and sowing dates

Sowing date	Spacing (inches) 10	15	20	Spacing (inches) 10	15	20
	ROOTS (washed) : tons per acre (±0.433)			TOPS : tons per acre (±0.727)		
April 18	13.41	13.56	12.48	12.25	13.63	11.63
May 9	13.83	12.73	12.08	13.14	12.54	11.92
May 25	11.32	12.66	11.39	12.42	12.18	11.25
	SUGAR PERCENTAGE (±0.187)			TOTAL SUGAR : cwt. per acre (±1.49)		
April 18	15.99	15.51	15.70	42.7	41.8	39.2
May 9	16.01	15.72	15.68	44.1	40.0	37.9
May 25	16.06	16.33	16.28	36.3	41.3	37.0

Sowing date	Spacing (inches) 10	15	20
	PLANT NUMBER : thousands per acre (±1.07)		
April 18	59.2	37.1	27.8
May 9	63.2	38.3	29.4
May 25	57.1	37.1	28.0

Conclusions

The 10 and 15 inch spacings gave significantly higher yields of roots and tops than the 20 inch spacing, and did not differ significantly. Spacing had no appreciable effect on the sugar percentage.

The first two sowings, April 18 and May 9, gave significantly higher yields of roots and a significantly lower sugar percentage than the third sowing, May 25, the net result being increases in total sugar over the third sowing of 3.1 and 2.5 cwt. per acre respectively. The differences in yield and sugar percentage between the first two sowing dates were small. The results for tops were quantitatively similar to those for roots, but the decrease in yield at the third sowing was not in this case significant.

Sulphate of ammonia gave significant increases in roots and tops, and also significantly decreased the sugar percentage. The increase in total sugar to the double dressing was 3.5 cwt. per acre.

Sulphate of ammonia significantly decreased plant number, and the second sowing, May 9, gave a significantly higher plant number than the first or the third, the last two not being significantly different.

O

KALE

WOBURN

The residual effects of Lupins as green-manure

WK—LANSOME, 1935

Plan and yields in lb. (green weights)

1	R 91	PT 160	P 116	O 67	4
NW ↑	P 89	O 89	PT 126	R 70	
	O 68	P 105	R 90	PT 114	
13	PT 138	R 93	O 126	P 132	16

SYSTEM OF REPLICATION: 4 ×4 Latin square.
AREA OF EACH PLOT (after rejecting edge-rows): 0.00973 acre. Plots actually 0.0107 acre.
TREATMENTS: Lupins were grown over the whole area in 1934.
O=Whole plant removed.
R=Tops removed, roots only buried.
P=Whole plants buried.
PT=Whole plants and additional tops from plots receiving treatment (R) buried.
These treatments were applied to kale sown in 1934. Kale was grown again in 1935 without further treatment.
CULTIVATIONS, ETC.: Kale sown: Rows 18½ inches apart: May 13. Thinned: June 24-26. Plants 5 inches apart in the rows. Hoed: Oct. 15, 17 and 19. Harvested: Mar. 13. Variety: Thousand head. Previous crop: Kale.
STANDARD ERROR PER PLOT: 0.693 tons per acre or 14.4%.

Treatment	Nitrogen added per acre (lb.), 1934 As Tops	As Roots
O	—	—
R	—	11.31
P	122.34	11.31
PT	244.77	11.31

Summary of results

Lupins dug in	Yield tons per acre	*Increase over no dressing*
Mean ..	*4.80*	
None ..	4.01	
Roots only ..	3.94	*—0.07*
Whole plant	5.07	*+1.06*
Whole plant and extra tops	6.17	*+2.16*
St. Errors ..	±0.346	*±0.489*

Conclusions

The crop of kale was an exceedingly poor one, but showed residual effects of the tops dug in in 1934, the yield of kale being increased by 1.1 tons per acre with single tops and 2.2 tons per acre with double tops. Roots had no apparent effect.

CARROTS.

WOBURN

Effect of sulphate of ammonia, poultry manure, soot and rape dust

WN—LANSOME, 1935

Plan and yields in lb. roots (washed) above, tops centre, plant number below.

1	S_1 88 51 593	N_2 104 55 627	R_1 117 51 652	N_1 127 50 684	S_0 134 36 687	R_1 121 41 664	R_0 145 48 704	S_2 128 47 607	8
	R_0 115 50 660	N_0 128 51 676	M_0 134 49 670	S_0 121 44 697	N_0 147 43 700	M_2 151 44 674	S_1 141 48 675	M_1 132 44 709	
NW ↑	S_2 119 60 650	M_2 134 56 661	R_2 128 61 676	M_1 125 52 665	N_2 138 62 638	R_2 150 50 641	N_1 139 51 681	M_0 131 29 694	
	S_1 128 56 658	M_0 153 70 691	M_2 124 60 681	M_1 141 54 659	N_2 143 61 651	M_1 134 39 669	R_0 137 34 700	S_0 136 29 703	
	R_0 120 45 649	N_2 115 61 627	N_0 127 48 658	S_0 134 55 685	N_0 133 42 667	S_2 116 37 612	M_2 122 33 674	R_2 138 43 671	
41	N_1 100 43 626	R_2 102 65 633	S_2 102 65 656	R_1 108 51 636	S_1 109 42 632	M_0 96 27 677	N_1 108 35 679	R_1 108 34 633	48

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

AREA OF EACH PLOT : 1/160 acre (25 lks. × 25 lks.)

TREATMENTS : 1935—No nitrogen (O), and sulphate of ammonia (N) half applied in seed-bed and the remainder as a top dressing, soot (S), poultry manure (M) and rape dust (R) applied at the rate of 0.4 cwt. N per acre (1) or 0.8 cwt. N per acre (2). Plots receiving treatment 0 in 1935 had treatment 2 in 1934 and *vice versa*. Plots receiving treatment 1 had this in both years. For N_0, S_0, M_0 and R_0 (see plan), the treatment symbols refer to the 1934 treatment.

BASAL MANURING : All plots were made up to 1.0 cwt. P_2O_5 per acre and 1.0 cwt. K_2O per acre, using superphosphate and muriate of potash (an allowance being made for the P_2O_5 and K_2O contained in the organic manures.)

CULTIVATIONS : Ploughed : Jan. 5-7. Double harrowed : Mar. 21. Harrowed April 24-25. Rolled : April 25. Seed sown : May 1-2. Manures applied : (sulphate of ammonia at half-rate) : May 1. Thinned : June 18-24. Rows 11 ins. apart. Plants 5 ins. apart in the row. Second half of sulphate of ammonia applied : June 26. Hoed : June 12 and July 12-16. Lifted : October 30. Variety : Garton's Intermediate. Previous crop : Carrots.

STANDARD ERRORS PER PLOT : Roots (washed) : 0.971 tons per acre or 10.8%. Tops : 0.460 tons per acre or 13.4%. Plant number : 3.29 thousands per acre or 3.11%. Mean dirt tare : 0.0651.

Summary of Results

Quantity (cwt. N. p.a.) 1934	1935	Sulph. Amm.	Soot	Poultry Manure	Rape Dust	*Mean*
		ROOTS (washed): tons per acre (±0.486)				
0.8	0.0	9.55	9.37	9.18	9.23	*9.33*[1]
0.4	0.4	8.46	8.32	9.50	8.11	*8.60*[1]
0.0	0.8	8.93	8.30	9.48	9.25	*8.99*[1]
Mean		*8.98*[2]	*8.66*[2]	*9.39*[2]	*8.86*[2]	*8.97*
		TOPS: tons per acre (±0.230)				
0.8	0.0	3.28	2.93	3.12	3.16	*3.12*[3]
0.4	0.4	3.20	3.52	3.37	3.16	*3.31*[3]
0.0	0.8	4.27	3.73	3.45	3.91	*3.84*[3]
Mean		*3.58*[4]	*3.39*[4]	*3.31*[4]	*3.41*[4]	*3.42*
		PLANT NUMBER: thousands per acre (±1.64)				
0.8	0.0	108.0	110.9	109.3	108.5	*109.2*[5]
0.4	0.4	106.8	102.3	108.1	103.4	*105.2*[5]
0.0	0.8	101.7	101.0	107.6	104.8	*103.8*[5]
Mean		*105.5*[6]	*104.7*[6]	*108.3*[6]	*105.6*[6]	*106.1*

Standard errors: (1) ±0.243, (2) ±0.281, (3) ±0.115, (4) ±0.133, (5) ±0.820, (6) ±0.947.

Conclusions

The experiment is designed to measure the differences in the immediate and cumulative effects of certain organic fertilisers and sulphate of ammonia. The results this year show no significant effect of any kind on the yield of roots. Tops, however, show a significant response to nitrogen applied this year, but no traces of any residual effect. The differences in present response cannot be regarded as fully significant. Plant number is significantly depressed by the present application of all forms of nitrogen, with the exception of poultry manure, this depression being closely associated with the apparent response of tops.

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PYRETHRUM

WOBURN

The effect of lime, fish manure, and artificial fertilisers on the yield of flowers, and their content of Pyrethrins.

ROADPIECE—1935

Plan and yields in grammes

Dry stalkless heads

1	LOA1 1945	LFO2 1614	OFO2 1462	LOO1 1331	OOA1 1553	LOO1 2055	OOA2 1647	OOO2 1727	8
NW ↑	LFO1 1682	OOA2 1796	OOA1 1809	OFA2 2304	OFO1 2285	LOA2 2113	LOA1 2648	LFA1 2226	
	LFA2 2150	OFO1 2634	LFA1 2472	LOA2 2218	LFO1 2215	LOO2 2181	LFO2 2439	OFA2 1991	
25	OOO1 1622	LOO2 1987	OOO2 1958	OFA1 1921	OFA1 1926	LFA2 1994	OOO1 2209	OFO2 1741	32

System of Replication : 2 randomised blocks of 16 plots each.

Area of Each Plot (after rejecting edge rows) : 0.00560 acre. Plots actually 29.6 links × 22.7 links.

Treatments : All combinations of :

$\left\{\begin{array}{l}\text{No lime (O)}\\ \text{Lime (L)}\end{array}\right\} \times \left\{\begin{array}{l}\text{No fish manure (O)}\\ \text{Fish manure (F)}\end{array}\right\} \times \left\{\begin{array}{l}\text{No complete artificials (O)}\\ \text{Complete artificials (A)}\end{array}\right\} \times \left\{\begin{array}{l}\text{Manures applied in 1st year only 1933 (1)}\\ \text{Manures applied every year (2)}\end{array}\right\}$

Lime was applied in the first year only.

Rates of Application : Lime, 2.88 tons of ground lime, equivalent to 4 tons $CaCO_3$.
Fish Manure : Where applied in first year only, 5 cwt. per acre (0.4 cwt. N) ; where applied every year half this dressing is given per annum.
Artificials : Where applied in first year only, sulphate of ammonia (0.4 cwt. N), superphosphate (0.4 cwt. P_2O_5) and muriate of potash (0.5 cwt. K_2O) ; where applied every year half those rates are given per annum.

Cultivations, Etc. Weeded : Oct. 18. Hoed : Dec. 17. Manures applied : Mar. 12. Harvested : July 8. Previous crop : Pyrethrum.

Special Note : Owing to mildewing consequent upon heavy rain during harvesting there was a serious degeneration in quality during drying. The pyrethrin contents were not determined.

Standard Error per Plot : 1.04 cwt. per acre or 14.8 %.

Summary of Results

Yields of separate treatments : dry stalkless heads, cwt. per acre

	Manures applied	Neither	Artificials	Fish manure	Artificials & fish manure	*Mean*
No lime ..	First year All years	6.61²	5.91¹ 6.05¹	8.65¹ 5.63¹	6.77¹ 7.55¹	*7.11³* *6.41³*
	Mean	*6.61²*	*5.98²*	*7.14²*	*7.16²*	*6.76⁴*
Lime	First year All years	6.64²	8.08¹ 7.62¹	6.85¹ 7.13¹	8.26¹ 7.29¹	*7.73³* *7.35³*
	Mean	*6.64²*	*7.85²*	*6.99²*	*7.78²*	*7.54⁴*

Standard errors : (¹) ±0.736, (²) ±0.520, (³) ±0.424, (⁴) ±0.300.

Effects of artificials and fish manure : cwt. per acre

Manures applied	Neither	Artificials	Fish manure	Artificials and fish manure	*Mean*	*Increase*
First year .. All years ..	6.62	7.00 6.84	7.75 6.38	7.51 7.42	*7.42* *6.88*	*−0.54*
Standard errors	±0.368		±0.520		*±0.300*	*±0.424*

Conclusions

No significant effects.

PIG EXPERIMENT, 1933-4

Comparison of three levels of rationed feeding and ad. lib. feeding. Effects of differing numbers of pigs per pen (with equal floor space per pig).

ARRANGEMENT

Three randomised blocks of 4 litters of 6 pigs each, sex and litter being equalised as far as possible over the different treatments. Each block contains one pen of 8 pigs (13 ft. x 6 ft. 3 ins.), two pens of 4 pigs (6 ft. 6 ins. x 6 ft. 3 ins.) and 4 pens of 2 pigs (3 ft. 3 ins. x 6 ft. 3 ins.). Each of these sets of pens contains two pigs on each of the four levels of rationing. Pigs were fed individually in small pens (1 ft. 8 ins. x 3 ft. 7 ins.) opening off the main pens. Food consumption and live weights were recorded weekly. At the end of the experiment the pigs were graded for shoulder fat, belly fat and payment.

DETAILS OF ARRANGEMENT

Block and Duration.	Block I (21 weeks)								Block II (21 weeks)								Block III (21 weeks)							
Litter No.	9		33		16		17		30		23		22		44		6		4		3		17	
Age at start (wks.) ..	14.3		13.7		11.3		12.4		13.0		11.1		12.7		14.8		13.9		12.4		12.3		13.0	
Sex	H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G	H	G
Ration A	–	4	8	2	4	–	2	8	4	2	4	2	8	–	8	–	2	–	4	8	8	4	–	2
Ration B	2	8	–	4	8	2	4	–	8	–	8	–	4	2	4	2	–	2	4	8	8	4	2	–
Ration C	2	8	–	4	8	2	4	–	4	2	4	2	8	–	8	–	8,4		–	2	2	–		8,4
Ration D	4	–	8	2	–	4	2	8	8	–	8	–	4	2	4	2	4	8	2	–	–	2	8	4

The number 2, 4 or 8 indicates that the pig was one of a pen of 2, 4 or 8 respectively. H denotes hog (i.e., castrated male) ; G denotes gilt (i.e. female).

TABLE OF RATIONS

Lb. food per week per 10-lb. live weight at beginning of week

	Weeks of Experiment			
	0–5	5–10	10–15	15–20
Ration A	ad lib.	2.1	1.89	1.68
Ration B	ad lib.	2.45	2.17	1.89
Ration C	ad lib.	2.8	2.52	2.24
Ration D	ad lib.	ad lib.	ad lib.	ad lib.

DETAILS

Block	I	II	III	Mean
Commenced	Nov. 30	Jan. 9	Feb. 7	—
Time (weeks)	21	21	21	21
Average age at start (weeks) ..	12.9	12.9	12.9	12.9
Average wt. (lb.) at start ..	44.4	35.1	47.3	42.3
Average wt. (lb.) at end	155.3	156.6	153.6	155.2
Regression of final on initial wt. ..	1.52	2.75	2.76	2.34

STANDARD ERRORS OF TOTAL LIVE-WEIGHT INCREASE
(Per pig-lb. and per cent. of increase)

Without elimination of differences of initial weight	15.3 lb. or 14.4%
With elimination of differences of initial weight	12.0 lb. or 11.3%

SUMMARY OF RESULTS

	Weeks of Experiment				Mean
	0–5	6–10	11–15	16–20	6–20
	Live weight increase (lb.) per pig				
Ration A	27.8	14.1	18.6	17.7	16.8
Ration B	31.2	21.7	25.0	26.6	24.4
Ration C	28.8	25.6	29.2	31.6	28.7
Ad lib...	27.2	36.1	40.2	47.0	41.1
	Food eaten (lb.) per pig				
Ration A	94.8	78.0	88.2	92.7	86.3
Ration B	99.9	99.9	116.8	124.4	113.7
Ration C	99.6	114.7	137.1	156.7	136.2
Ad lib...	96.8	149.4	182.9	236.6	189.6
	Live weight gain in lb. per 1 lb. food				
Ration A	0.291	0.171	0.208	0.193	0.194
Ration B	0.317	0.218	0.217	0.214	0.214
Ration C	0.287	0.226	0.213	0.204	0.210
Ad lib,..	0.279	0.239	0.230	0.198	0.216
St. errors	0.0105	0.0143	0.0107	0.00964	—

EFFECTS OF NUMBERS IN PEN
Mean final weights per pig adjusted for differences of initial weight

Block	I	II	III	Mean
Two in a pen	155.8	165.3	153.1	158.1
Four in a pen	156.8	143.4	156.5	152.2
Eight in a pen	154.0	158.0	162.8	158.2

NUMBER OF PIGS IN EACH GRADE
(Classed according to number in pen)

Grade	Belly fat.						Shoulder fat.						Payment					
	H			G			H			G			H			G		
	2	4	8	2	4	8	2	4	8	2	4	8	2	4	8	2	4	8
A	2	3	6	6	4	6	3	2	3	3	5	3	1		1			3
B													2	3	6	8	7	3
C	4	4	9	5	4		4	6	13	8	3	3	3	1	8	1		
D	1	5	1	2	1			5		2	1		1	8	1	4	2	
E		1												1				

NUMBER OF PIGS IN EACH GRADE
(Classed according to ration)

Grade	Belly fat								Shoulder fat								Payment							
	H				G				H				G				H				G			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
A	4	2	3	2	4	3	4	5	1	3	2	2	3	2	3	3		1	1		1	1	1	
B																	4	1	3	3	3	3	5	7
C	3	4	4	6	3	1	3	2	7	4	6	6	3	3	3	5	2	3	3	4	1			
D	2	2	2	1	1	1		1	1	2	1	1	2		1		3	3	2	2	3	1	1	1
E		1																1						

MEAN PAYMENT GRADE.

Sex		Number in pen		Ration	
H	+0.11	2	+0.37	A	+0.18
G	+0.79	4	+0.01	B	+0.29
		8	+0.97	C	+0.60
				D	+0.43

NOTE: Grade C is taken as the origin in the above table.

Conclusions

In the first five weeks after limitation of feeding commenced, the efficiency of the feeding rates, measured as the live weight gain per 1 lb. food, increased significantly as the level of feeding was raised. In the last ten weeks, however, there was no difference between the efficiencies of the different feeding rates.

Variation of numbers in pen (with equal floor space per pig) had no apparent effect on the live weight increases.

No significant differences in grade were produced by the different feeding rates. The pigs kept eight in a pen were graded significantly higher than those kept two or four in a pen on belly fat and payment. The gilts were graded on the average 0.4 of a point higher on shoulder fat, 0.8 higher on belly fat and 0.7 higher on payment than the hogs, the last two differences being significant.

PIG EXPERIMENT, 1935-6

Comparison of minimal and liberal green food.
Effect of exercise.
Comparison of fine and coarse grinding of food.
Comparison of ad lib. feeding and limitation of food after 125 lb. weight.

ARRANGEMENT

Four replications, each of two litters of eight pigs, the third order interaction being confounded with litters. Within each litter, the treatments are partially confounded with sex.

TREATMENTS : All combinations of :

$$\left\{\begin{matrix}\text{Minimal green food } (-) \\ \text{Liberal green food } (G)\end{matrix}\right\} \times \left\{\begin{matrix}\text{No exercise } (-) \\ \text{Exercise } (E)\end{matrix}\right\}$$

$$\times \left\{\begin{matrix}\text{Coarse grinding } (-) \\ \text{Fine grinding } (F)\end{matrix}\right\} \times \left\{\begin{matrix}\text{Ad lib. feeding } (-) \\ \text{Limited feeding after 125 lb. } (R)\end{matrix}\right\}$$

Food consumption and live weights were recorded weekly. At the end of the experiment measurements were made of back fat, streak and length of side and the pigs were graded for payment.

FEEDING RATIONS

	Percentage Rations	
	Before 100lb. live weight	After 100lb. live weight
Weatings	50	30
Barley meal	30	50
Flaked maize	10	10
White fishmeal	10	10

Limitation of food commenced when the pig reached 125 lb. live weight. Pigs on limited food consumed on the average about 90 per cent. by weight of the amount of food consumed by pigs with ad lib. feeding.

DETAILS

	Sub-blocks A *				Sub-blocks B *				Mean
	I	II	III	IV	I	II	III	IV	
Commenced ..	July 30	Aug. 2	Sept. 13	Oct.29	July 30	Aug. 2	Sept. 13	Oct. 8	—
Time (weeks) ..	18	18	14	18	18	18	14	18	17
Average age at start (weeks)	11.8	12.8	14.4	12.8	11.8	12.1	13.1	11.0	12.5
Average wt. lb.									
At start ..	40.6	41.2	58.8	42.0	43.2	35.9	53.4	42.4	44.7
At end ..	191.5	175.6	180.8	179.0	206.4	170.2	160.1	169.4	179.1

*For treatments see summary of results below.

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STANDARD ERRORS OF TOTAL LIVE-WEIGHT INCREASE

(Per pig—lb. and per cent. of increase)

Without elimination of differences of initial weight	15.9 lb. or 11.9%
With elimination of differences of initial weight	15.6 lb. or 11.6%

SUMMARY OF RESULTS

Means of individual treatments

Sub-blocks A

G	E	F	R	GEF	GER	GFR	EFR
Live weight increase (lb.) per pig							
138	136	138	138	130	144	134	131
Food consumed (lb.) per pig							
482	502	501	476	486	496	482	484
Live weight gain in lb. per 1 lb. food							
0.286	0.271	0.275	0.290	0.267	0.290	0.278	0.271

Sub-blocks B

—	GE	GF	GR	EF	ER	FR	GEFR
Live weight increase (lb.) per pig							
152	124	137	123	143	127	139	117
Food consumed (lb.) per pig							
522	462	465	426	508	449	460	402
Live weight gain in lb. per 1 lb. food							
0.291	0.268	0.295	0.289	0.281	0.283	0.302	0.291

RESPONSES TO TREATMENTS

Mean values : Live weight increase : 134 lb. ; food consumed : 475 lb. ; live weight gain per 1 lb. food : 0.283 lb.

	Live weight increase (lb.) per pig	Food consumed (lb.) per pig	Live weight gain in lb. per 1 lb. food
Liberal green food ..	−7.12[1]	−25.12	0.000
Exercise	−5.88[1]	− 3.12	−0.009
Fine grinding	−1.62[1]	− 3.38	−0.001
Limited feeding after 125 lb.	−5.62[1]	−31.62	+0.008

[1]Standard error, ±3.99

GRADING FOR PAYMENT

Number of pigs in each grade, classed according to sex and the main treatments

	Hogs		Gilts		Hogs		Gilts	
	O	E	O	E	O	R	O	R
A	2	1	8	7	2	1	8	7
B	3	4	3	6	5	2	2	7
C	3	9	4	1	3	9	4	1
D	5	2	4	1	4	3	3	2
E		1			1			

	Hogs		Gilts		Hogs		Gilts	
	O	F	O	F	O	G	O	G
A	2	1	7	8	1	2	7	8
B	2	5	5	4	3	4	5	4
C	5	7	3	2	6	6	4	1
D	4	3	3	2	4	3	1	4
E	1				1			

MEAN PAYMENT GRADE

Minimal green food	+0.50	Liberal green food	+0.64
No exercise	+0.47	Exercise	+0.70
Coarse grinding	+0.44	Fine grinding	+0.68
Ad lib. feeding	+0.54	Limited feeding after 125 lb. ..	+0.60
Hogs	+0.13	Gilts	+1.01

Note : Grade C is taken as origin in the above table.

RESPONSES TO TREATMENTS

Mean values : Back fat : 1.46 ins. ; streak : 1.52 ins. ; length of side : 30.59 ins.

	Back Fat	Streak	Length of Side
Liberal green food	−0.011	0.049	−0.234
Exercise	−0.074	−0.056	−0.114
Fine grinding	−0.029	−0.019	+0.109
Limited feeding after 125 lb.	−0.021	−0.014	−0.121
St. errors	±0.0264	±0.0655	±0.176

Conclusions

There were no significant effects of the treatments on live weight increase, efficiency of food utilisation or mean payment grade. Pigs receiving exercise had significantly less back fat than pigs without exercise.

Gilts were graded for payment about 0.9 of a point higher than hogs, the difference being significant.

EXPERIMENTS ON POULTRY MANURE

Centres	Type of Experiment	No. of plots
Rothamsted (see pp. 191 for details)	2aCR	48
Woburn (see pp. 199-200 for details)	2aCR	48
Lady Manner's School, Bakewell (A)	IC	16
Lady Manner's School, Bakewell (B)	IC	16
T. Hughes, Esq., Chittoe, Wilts.	2CR	24
Fakenham School, Norfolk	IC	16
County School, Godalming, Surrey	IC	16
Gresham School, Holt	IC	16
Sailors' Orphan Homes School, Newlands, Hull	I	16
A. G. Brightman, Esq., Maulden, Beds. (A) J. W. Dallas, Esq., County Organiser	3	24
A. G. Brightman, Esq., Maulden, Beds. (B). J. W. Dallas, Esq., County Organiser	3	24
Cheshire School of Agriculture, Reaseheath, Nantwich, Cheshire (A)	IbR	50
Cheshire School of Agriculture, Reaseheath, Nantwich, Cheshire (B)	Ia	25
Cheshire School of Agriculture, Reaseheath, Nantwich, Cheshire (C)	Ia	25
The High School, Newcastle, Staffs. (A)	IC	16
The High School, Newcastle, Staffs. (B)	I	16
Norton New Council School, Doncaster, York	IC	16
Hertfordshire Farm Institute, Oaklands, St. Albans	2a	36
G. McCrae, Esq., Gillibrand Farm, Skelmersdale, Ormskirk, Lancs. J. J. Green, Esq., County Organiser	Ia	25
L. Pope, Esq., Pelton, Durham	I	12
Worcester County Experimental Station, Perdiswell. R. C. Gaut, Esq., County Organiser	2CR	24
Messrs. Smith Bros., Stratford, Sandy. J. W. Dallas, Esq., County Organiser	IaR	25
Church of England School, Staindrop, Darlington, Co. Durham..	IC	16
J. Bonner, Esq., Steppingley, Beds...	2CR	24
The Horticultural College, Swanley	3	24
County School, Welshpool, Montgomeryshire	IC	16
R. S. Maudlin, Esq., Wyboston. J. W. Dallas, Esq., County Organiser	2CR	24

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Experimental arrangements

(I) All combinations of $\left\{\begin{matrix} O \\ PM \end{matrix}\right\} \times \left\{\begin{matrix} O \\ S/A \end{matrix}\right\}$
4 x 4 Latin squares or randomised blocks.
*Basal manuring : 1.0 cwt. K_2O and 0.8 cwt. P_2O_5 per acre.

(Ia) As (I), with malt culms or rape meal as an additional treatment.
5 x 5 Latin squares or randomised blocks.
*Basal manuring : 1.0 cwt. K_2O and 0.8 cwt. P_2O_5 per acre. Sandy (potatoes) also received 2 cwt. sulphate of potash and 2 cwt. chilean potash nitrate applied in 1935.

(IC) Cumulative : As (I), with treatments in 1935 on the same plots as in 1934.

(IaR) Residual : As (Ia), with treatments applied in 1934 and no treatments in 1935.

(IbR) As (IaR), with plots split for sulphate of ammonia in 1935.

(2) 0, 1 and 2 levels of S/A and PM.
Randomised blocks.
*Basal manuring : 1.0 cwt. K_2O and 1.0 cwt. P_2O_5 per acre.

(2CR) Immediate, cumulative and residual effects. Manures as 2, treatments as follows :

1934	O	O	1S	1M	2S	2M
1935	2S	2M	1S	1M	O	O

(2a) As (2), with soot.

(2aCR) As (2CR), with soot and rape dust.

(3) Immediate, cumulative and residual effects. Treatments as follows :

1935	O	O	M	M	O	O	S	S
1936	O	M	O	M	O	S	O	S
1937	M	M	O	O	S	S	O	O
1938	M	O	M	O	S	O	S	O

Randomised 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_2O and 0.8 cwt. or 1.0 cwt. P_2O_5, using muriate of potash and superphosphate.

Rates of manuring

(I), (IC), (Ia), and (IAR) N at the rate of 0, 0.6 and 1.2 cwt. per acre.

(IbR) N at the rate of 0, 0.6 and 1.2 cwt. per acre applied in 1934.
N at the rate of 0 and 0.2 cwt. per acre applied in 1935.

(2), (2CR) and (2aCR) N at the rate of 0, 0.4 and 0.8 cwt. per acre.

(2a) N at the rate of 0, 0.45 and 0.9 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 (A)	Kale	1/102	Limestone loam	Marrow-stem	May 12	May 17	Nov. 15-Jan. 10	Potatoes
Bakewell (B)	Mangolds	1/102	Limestone loam	Yellow Globe	April 9 & May 3	May 8	Oct. 17-23	Kale
Chittoe	Carrots	1/25	Lower greensand	Early Market	May 20	May 22	Nov. 20-Dec. 2	Potatoes
Fakenham	Potatoes	1/302	Sandy loam	Majestic	April 1	April 3	Oct. 28	Potatoes
Godalming	French beans	1/239	Sandy	Best of All	April 24	June 12	Aug. 22-26-Sept. 10	Potatoes
Holt**	Potatoes	1/160	Loam	Sharpe's Express	April 3-8	April 5-6	July 20-25	Potatoes
Hull	Potatoes	1/161	Heavy alluvium	Arran Banner	April 12	April 12	Sept. 12-13	Mixed vegetables
Maulden (A)	Potatoes	1/73	Lower greensand	Ninetyfold	April 24	April 25	July 26-31	Kale
Maulden (B) §	Savoys	1/70	Lower greensand	—	April 24	Mid. Aug.	Feb. 22, 1936	Potatoes
Nantwich (A)†	Oats	1/90	Light loam	Marvellous	April 26	March 27	July 29	Kale
Nantwich (B)	Onions	1/134	Light loam	Bedfordshire Champion	April 17	April 24	Sept. 26	Onions
Nantwich (C)	Potatoes	1/104	Light loam	Kerr's Pink	May 13	May 15	Oct. 11	Potatoes
Newcastle (A)	Swedes	1/415	Old garden	Leighton's Garden	May 17	May 26	Oct. 3	Potatoes
Newcastle (B)	Potatoes	1/300	Old garden	Majestic	April 7	April 8	Oct. 15	Neglected land—weeds
Norton	Peas	1/316	Medium loam	Laxton's Progress	April 8	April 8	July 12	Potatoes
Oaklands‡	Sprouts	1/75	Silty loam	Cambridge Strain	July 3-6	May 24	Nov. 5-Dec. 3	Kale
Ormskirk	Potatoes	1/80	Medium loam	Kerr's Pink	May 13	May 13	Oct. 29	Cabbage
Pelton	Potatoes	1/186	Medium loam	Arran Banner	April 30	April 30	Sept. 26	Mixed garden crops
Perdiswell*	Runner beans	1/40	Alluvial loam	Sutton's A.1	April 17	May 15	July 31-Sept. 2	Sugar beet
Sandy	Potatoes	1/70	Sandy	Ninetyfold	March 13 (1934)	March 10	July 3	Sugar beet
Staindrop	Beet (red)	1/160	Loam	Carter's Red Globe	May 21	May 22	Oct. 21	Potatoes
Steppingley	Potatoes	1/50	Sandy loam	Eclipse	May 7	May 8	Aug. 22-30	Spring cabbage
Swanley	Onions	1/160	Sandy	Ailsa Crag	May 20	June 6-7	Sept. 27	Parsnips and carrots
Welshpool	Potatoes	1/160	Medium loam	Great Scot	April 3	May 8	Oct. 4-12	Swedes
Wyboston	Potatoes	1/60	Silty gravel	Majestic	April 2, 12	April 15	Oct. 9	Sprouts

* Soil irregularities were pronounced due to strips of gravel crossing the plots.
† The oats were weighed green, grain and straw together.
§ Yields small, due to drought and damage by pigeons.
** Crop was a failure through drought. Weeds troublesome.
‡ Damage by drought, birds and rabbits.

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Summary

One year experiments

The standard errors given in the tables apply to the individual treatment means

Types 1 *and* 1*a*

Place	Crop	No nitrogen	Poultry manure	Sulph. amm.	Poultry manure and sulph. ammonia	Other organic fertilizers	*Mean*	St. error	*Mean response to N*†	P.M.—S/A Per cent of mean response	P.M.—S/A St. error
Hull ..	Potatoes: tons per acre	6.87	8.56	8.28	8.63		*8.08*	±0.416	+1.55	+18.1	±38.4
Nantwich (C) ..	,, ,, ,,	7.08	7.89	8.44	8.09	7.91[1]	*7.88*	±0.222	+*1.08*	—50.9	±31.8
Newcastle	,, ,, ,,	9.92	10.90	12.30	13.11		*11.56*	±0.760	+*1.68*		
Ormskirk	,, ,, ,,	7.84	7.74	9.44	8.50	8.38[2]	*8.38*	±0.564	+*0.75*	−226.7	±234.2
Pelton ..	,, ,, ,,	12.54	13.92	16.22	14.20		*14.22*	±0.454	+*2.53*	−90.9	±32.2
Mean of potato experiments ..		*8.85*	*9.80*	*10.94*	*10.51*		*10.02*	±*0.230*			
Nantwich (C) ..	Per cent. ware	66.3	71.4	71.1	70.2	71.8[1]	*70.2*	±1.10	+*5.0*	+6.0	±31.2
Pelton ..	,, ,, ,, *	79.2	78.2	75.2	82.8		*78.8*	—	−*2.5*		
Nantwich (B) ..	Onions: tons per acre ..	9.81	10.68	9.84	10.11	10.31[1]	*10.15*	±0.288	+*0.45*		

† The average of the responses to P.M. and S/A alone. [1]Malt culms. [2]Rape meal.
* Potatoes hand sorted ; replicates bulked.

The differences in response to P.M. and S/A are shown as a percentage of the mean response at those stations at which there was a clear response to N.

Conclusions

Poultry manure and sulphate of ammonia alone and in combination.

There were significant responses to nitrogen in the yield of potatoes at four of the five centres, Ormskirk being the exception. In three of these sulphate of ammonia alone gave higher yields than poultry manure alone, but in only one case (Pelton) was the difference in yield significant. At the same centre sulphate of ammonia alone gave a significantly higher yield than the combined dressing. At Ormskirk, sulphate of ammonia gave an almost significant increase in yield, but there was no apparent response to poultry manure and the response to rape meal was not significant. At Nantwich nitrcgen produced a significant increase in percentage ware, with no apparent difference in response between poultry manure, sulphate of ammonia or malt culms. At Pelton, where the replicates of the treatments were bulked for percentage ware, no consistent effect of nitrogen was apparent.

There were no significant effects on onions at Nantwich.

Type 3

Place	Crop	No nitrogen	Poultry manure	Sulph. amm.	*Mean*	St. error
Maulden (A)	Potatoes : tons per acre ..	3.64[1]	4.36	4.67	*4.08*	±0.245
Swanley	Onions : Total crop : tons per acre	5.94[2]	6.73	5.69	*6.07*	±0.563
	Percentage 1st to total ..	63.2[3]	69.2	70.1	*66.4*	±2.47
Maulden (B)	Savoys : cwt. per acre ..	6.4[4]	7.7	7.5	*7.0*	±0.743

Standard errors : ([1]) ±0.173, ([2]) ±0.398, ([3]) ±1.75, ([4]) ±0.525.

Conclusions

New experiments on immediate, cumulative and residual effects.

This year the experiments measure only the direct response to 1935 applications of poultry manure and sulphate of ammonia. There was a significant response to nitrogen, with no difference between the two types, in potatoes at Maulden and onions (percentage of first quality to total) at Swanley. There were no significant effects on the total yield of onions at Swanley or on savoys at Maulden.

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1935

1st Year.

Type 2a

Place	Crop	No nitrogen	1 Poultry manure	2 Poultry manure	1 Sulph. amm.	2 Sulph. amm.	1 Soot	2 Soot	*Mean*	St. error
Oaklands	Brussels sprouts : cwt. per acre									
	1st harvesting	19.8	22.0	24.2	23.8	21.3	24.6	28.0	*22.6*	
	2nd harvesting	6.6	7.6	7.0	6.5	7.5	7.4	8.6	*7.2*	
	Total saleable	26.4[1]	29.6	31.2	30.3	28.8	32.0	36.6	*29.8*	±2.56

Standard error : (1) ±1.48.

Conclusions

Single and double dressings of poultry manure, sulphate of ammonia and soot.

The only experiment of this type was on brussels sprouts at Oaklands. There was a response to nitrogen in total saleable sprouts, but no significant differences between the types of dressing. The additional response to the double dressing was small and not significant.

Cumulative experiments
(all in second year)
Type 1c

Place	Crop	No nitrogen	Poultry manure	Sulph. amm.	Poul. man. and sulph. amm.	*Mean*	St. error	*Mean response to N*†	P.M.–S/A Per cent. of mean response	P.M.–S/A St. error
Fakenham ..	Potatoes : tons per acre	3.98	4.34	4.47	5.33	*4.53*	±0.285	*+0.42*	−31.0	±99.2
Holt	,, ,, ,, ,,	1.66	1.50	2.18	2.78	*2.03*	±0.198	*+0.18*		
Welshpool ..	,, ,, ,, ,,	5.18	6.02	6.36	6.36	*5.98*	±0.208	*+1.01*	−33.7	±30.3
Mean of potato experiments		*3.61*	*3.95*	*4.34*	*4.82*	*4.18*	*±0.135*			
Newcastle (A) ..	Swedes									
	Roots : tons per acre ..	10.93	10.79	11.49	10.47	*10.92*	±0.675	*+0.21*		
	Tops : tons per acre	4.45	5.28	5.60	5.79	*5.28*	±0.412	*+0.99*	−32.3	±61.1
Bakewell (B)	Mangolds									
	Roots : tons per acre	19.16	21.88	21.13	22.20	*21.09*	±0.595	*+2.34*	+32.0	±37.3
	Tops : tons per acre	4.48	5.46	5.96	6.94	*5.71*	±0.198	*+1.23*	−40.6	±24.1
Staindrop ..	Red beet : tons per acre	14.79	15.67	16.89	11.54	*14.72*	±0.565	*+1.49*		
Bakewell (A) ..	Kale : tons per acre	13.01	16.86	16.26	18.99	*16.28*	±0.695	*+3.55*	+16.9	±28.0
Norton ..	Peas : cwt. per acre	101.1	96.8	91.2	97.8	*96.7*	±4.10	*−7.1*		
Godalming ..	French beans : cwt. per acre	42.2	51.6	42.9	43.7	*45.1*	±2.31	*+5.0*		
	Haulms : cwt. per acre	47.5	77.3	59.7	74.0	*64.6*	±3.28	*+21.0*	+83.8	±27.2

† The average of the responses to P.M. and S/A alone.
The differences in response to P.M. and S/A are shown as a percentage of the mean response at those stations at which there was a clear response to N.

Conclusions

Poultry manure and sulphate of ammonia alone and in combination. Second year cumulative effects.

There were significant responses to both poultry manure and sulphate of ammonia applied alone, with no significant difference between them, at Fakenham and Welshpool (potatoes), Newcastle (swedes, tops), Bakewell (mangolds, roots and tops), and Bakewell (kale). The combined dressing gave a significant additional response in mangolds tops, though not in roots, at Bakewell. At Newcastle nitrogen had no apparent effect on the root yield of swedes. At Holt the potato crop failed.

At Staindrop sulphate of ammonia alone produced a significant increase in the yield of red beet, while the increase to poultry manure alone was not significant. The two yields did not, however, differ significantly. The combined dressing produced a striking depression in yield.

At Norton all dressings of nitrogen reduced the yield of peas, but the depressions were not significant.

The apparent response to poultry manure in the yield of French beans was large, though not fully significant. There was no sign of response to sulphate of ammonia. The Haulms were significantly increased by nitrogen, poultry manure giving a significantly higher yield than sulphate of ammonia.

Experiments on Residual Effects
(Manures applied last year)
Types 1a R and 1b R

Place	Crop	No nitrogen	Poultry manure	Sulph. amm.	Poul. man. and sulph. amm.	Malt culms	*Mean*	St. error
Sandy	Early potatoes : tons per acre ..	2.53	2.44	2.25	2.26	2.51	*2.40*	±0.0836
Nantwich (A)	Green oats : cwt. per acre							
	No S/A in 1935	55.4	54.4	57.3	59.2	56.3	*56.5*	
	1 cwt. in 1935	58.9	59.5	60.5	58.2	62.7	*60.0*	
	Average	57.2	57.0	58.9	58.7	59.5	*58.3*	±0.970
	Response to S/A	+3.5	+5.1	+3.2	−1.0	+6.4	*+3.5*	±3.19

Conclusions

Poultry manure and sulphate of ammonia alone and in combination. Residual effects of 1934 *dressings.*

There was a significant depression in the yield of potatoes on the plots receiving sulphate of ammonia in 1934. The depression due to poultry manure applied in 1934 was not significant, but was not significantly less than that due to sulphate of ammonia. At Nantwich (oats) only the total green weights were recorded. Sulphate of ammonia applied in 1935 gave a significant average response. The residues of the 1934 applications of nitrogen had no apparent effect on yields or on the response to sulphate of ammonia applied in 1935.

Experiments on immediate, cumulative and residual effects
Type 2 C R

Place	Crop	Treatments 1934	1935	Poultry manure	Sulph. amm.	*Mean*	St. error
Steppingley	Potatoes : tons per acre..	2N	0N	4.08	4.30	*4.19*	±0.255
		1N	1N	4.35	4.97	*4.66*	
		0N	2N	5.00	4.83	*4.92*	
		Mean		*4.48*	*4.70*	*4.59*	
Wyboston	Potatoes : tons per acre..	2N	0N	5.40	4.91	*5.16*	±0.228
		1N	1N	5.30	5.70	*5.50*	
		0N	2N	6.05	6.72	*6.38*	
		Mean		*5.58*	*5.78*	*5.68*	
	Per cent. ware	2N	0N	86.1	85.6	*85.8*	±2.84
		1N	1N	85.2	86.0	*85.6*	
		0N	2N	86.2	87.6	*86.9*	
		Mean		*85.8*	*86.4*	*86.1*	
Chittoe ..	Carrots : tons per acre..	2N	0N	10.16	12.07	*11.12*	±0.491
		1N	1N	11.25	10.58	*10.92*	
		0N	2N	9.45	9.61	*9.53*	
		Mean		*10.29*	*10.75*	*10.52*	
Perdiswell	Runner beans: cwt. per acre	2N	0N	38.2	34.8	*36.5*	±5.88
		1N	1N	41.6	41.8	*41.7*	
		0N	2N	41.4	40.6	*41.0*	
		Mean		*40.4*	*39.1*	*39.7*	

Conclusions

Immediate, cumulative and residual effects.

At Steppingley nitrogen applied in 1935 produced a significantly greater yield of potatoes than the residues of nitrogen applied in 1934. There were no significant differences between poultry manure and sulphate of ammonia. At Wyboston nitrogen applied in 1935 also gave increased yields, the yield with sulphate of ammonia being significantly greater than that with poultry manure. On the other hand, the residues of the double dressing of poultry manure in 1934 gave higher yields than those of sulphate of ammonia, though the difference was not significant. There were no treatment effects on percentage ware.

At Chittoe the double dressing of nitrogen given in 1935 gave significantly lower yields of carrots than the residues of the double 1934 dressings. For the 1935 applications, the difference in yield between poultry manure and sulphate of ammonia was small and not significant, but the 1934 dressing of sulphate of ammonia gave a significantly higher yield than the 1934 dressing of poultry manure. The results for Woburn (carrots) are given on p. 199—200.

There were no significant effects on runner beans at Perdiswell, the standard error per plot being very high.

SUGAR BEET FERTILISER EXPERIMENTS

FACTORY SERIES

SYSTEM OF REPLICATION: 3 randomised blocks of 9 plots each, with two degrees of freedom, representing second order interactions, confounded with block differences. At Poppleton a mistake was made in laying-out the plots and the experiment was analysed as a single randomised block of 27 plots.

AREA OF EACH PLOT: Bury, Colwick 1 (Cast.), Colwick 2 (Dent.), Ipswich and Kidderminster: 1/10 acre. Cantley, Ely, Felstead, Peterboro' 1 (Thor.), Peterboro' 2 (Tall.), Poppleton and Selby: 1/20 acre. Allscott, Bardney 1 (Meth.), Bardney 2 (Horn.), Brigg 1 (Caistor), Brigg 2 (Scotton), Kings Lynn, Newark and Wissington 1 (Crimp.): 1/40 acre. Wissington 2 (Wimb.): 1/80. Tunstall: 1/100 acre. Oaklands: 1/150 acre.

TREATMENTS: All combinations of :—

$$\left\{\begin{array}{l}\text{No sulph. amm. } (N_0)\\ \text{2 cwt. sulph. amm.}\\ \quad (0.4 \text{ cwt. N}) \ (N_1)\\ \text{4 cwt. sulph. amm.}\\ \quad (0.8 \text{ cwt. N}) \ (N_2)\end{array}\right\} \times \left\{\begin{array}{l}\text{No super. } (P_0)\\ \text{3 cwt. super.}\\ (0.5 \text{ cwt. } P_2O_5) \ (P_1)\\ \text{6 cwt. super.}\\ \quad (1.0 \text{ cwt. } P_2O_5) \ (P_2)\end{array}\right\} \times \left\{\begin{array}{l}\text{No mur. pot. } (K_0)\\ 1\tfrac{1}{4} \text{ cwt. mur. pot.}\\ (0.6 \text{ cwt. } K_2O) \ (K_1)\\ 2\tfrac{1}{2} \text{ cwt. mur. pot.}\\ (1.2 \text{ cwt. } K_2O \ (K_2)\end{array}\right\}$$

VARIETIES: Bardney 2 (Horn.): Johnson's. Colwick 1 (Cast.) and Colwick 2 (Dent.): Kuhn. Cantley, Ely and Kings Lynn: Kuhn P. Peterborough 1 (Thor.): Kleinwanzleben Z. Wissington 1 (Crimp.): Marsters. Remainder: Kleinwanzleben E.

Mechanical and chemical analyses of soil samples from each experiment have been carried out.

Plant Density (mean values)

	Station	Yield in tons per acre	Plants in thousands per acre	Distance in inches between rows	Weight of roots in lb. per plant	St. Error per plot Roots tons p.a.
1	Allscott	7.79	30.0	19.8	0.58	1.26
2	Bardney 1 (Meth.)	9.36	27.7	20.0	0.76	0.355
3	Bardney 2 (Horn.)	11.06	25.0	20.0	1.00	0.728
4	Brigg 1 (Caistor)	10.34	25.4	18.0	0.91	0.836
5	Brigg 2 (Scotton)	9.41	33.7	18.0	0.63	0.792
6	Bury	9.27	26.1	19.5	0.80	0.717
7	Cantley	12.77	31.6	17.7	0.91	0.902
8	Colwick 1 (Cast.)	12.44	33.2	20.9	0.84	1.26
9	Colwick 2 (Dent.)	9.66	25.8	20.9	0.84	0.676
10	Ely	11.75	31.2	21.5	0.85	1.02
11	Felstead	9.84	20.6	22.1	1.07	1.22
12	Ipswich	8.18	—	19.7	—	1.03
13	Kidderminster	5.31	28.3	22.0	0.42	0.492
14	King's Lynn	8.01	32.8	18.9	0.55	0.614
15	Newark	7.38	29.9	19.0	0.56	0.886
16	Oaklands	6.06	23.6	22.0	0.58	0.514
17	Peterborough 1 (Thor.)	12.08	23.8	20.2	1.14	1.20
18	Peterborough 2 (Tall.)	12.98	26.6	19.8	1.10	1.75
19	Poppleton	10.74	26.9	22.5	0.89	1.42
20	Selby	11.97	33.6	20.7	0.80	0.761
21	Tunstall	5.43	59.1	16.5	0.21	0.534
22	Wissington 1 (Crimp.)	8.62	28.2	21.4	0.68	0.745
23	Wissington 2 (Wimb.)	8.82	31.1	20.1	0.64	1.51

P

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	Station	Soil	Previous crop	Date of sowing	Date of lifting	Farming notes
1	Allscott ..	Sandy	Beet	May 20	Dec. 30	Very poor land, no dung for a long time.
2	Bardney 1 (Meth.)	Limestone loam	Barley	Apr. 24	Oct. 24	
3	Bardney 2 (Horn.)	Light loam	Wheat	May 3	Nov. 12	8 loads dung to wheat
4	Brigg 1 (Caistor)	Sandy	Wheat	Apr. 25	Oct. 29	
5	Brigg 2 (Scotton)	Sandy	Oats	Apr. 24	Nov. 13	
6	Bury ..	Sandy loam	Beet	Apr. 27	Nov. 15	
7	Cantley ..	Sandy loam	Barley	Apr. 15	Nov. 22	
8	Colwick 1 (Cast.)	Sandy loam	Barley	May 1	Nov. 16	16 cwt. quick lime per acre. Plants showed up effect of N well.
9	Colwick 2 (Dent.) ..	Sandy loam	Wheat	May 6	Nov. 10	Signs of unusual supply of N in the soil.
10	Ely ..	Heavy fen	Beet	Apr. 27	Nov. 11	4 cwt. super to beet (1934). Some plots damaged by wind.
11	Felstead ..	Heavy loam	Wheat	Apr. 29	Nov. 19	No dung in recent years.
12	Ipswich ..	Light loam	Wheat	May 10	Dec. 11	Dung applied to wheat. 12 tons chalk on wheat stubble gyrotilled in.
13	Kidderminster	Light loam	Oats	May 3	Nov. 20	1 ton per acre of lime. Dressing of waste lime to oats. Crop badly damaged by aphis and summer drought.
14	King's Lynn	Sandy loam	Barley	Apr. 15	Oct. 16	
15	Newark ..	Sandy loam	Barley	May 8	Dec. 9	Very light dressing of dung.
16	Oaklands ..	Poor loam	Wheat	May 10	Oct. 25	
17	Peterborough 1 (Thor.)	Black fen on clay	Wheat	Apr. 20	Nov. 25	
18	Peterborough 2 (Tall.)	Medium loam on clay	Barley	May 8	Dec. 12	3 cwt. artificials to barley. Land gyrotilled in spring. No dung in recent years.
19	Poppleton ..	Sandy loam	Wheat	Apr. 26	Oct. 23	Gyrotilled after wheat.
20	Selby ..	Sandy loam	Beet	May 2	Oct. 16	Artificials and lime to beet (1934).
21	Tunstall ..	Poor sand	Rye	May 10	Nov. 14	Nitrate of soda applied to Rye. Crop suffered from drought.
22	Wissington 1 (Crimp.)	Gravelly loam	Barley	Apr. 13	Oct. 28	
23	Wissington 2 (Wimb.) ..	Sandy	Beans	Apr. 23	Nov. 22	

Sampling errors in sampling for sugar content

(10 *roots in each sample*)

Station	No. of samples analysed per plot	Standard error per sample
2 Bardney (Meth.)	2	0.159
3 Bardney (Horn.)	2	0.190
4 Brigg (Caistor) ..	2	0.270
5 Brigg (Scotton)	2	0.176
7 Cantley ..	2	0.288
11 Felstead ..	2	0.338
13 Kidderminster	2	0.353
15 Newark ..	2	0.0962
22 Wissington (Crimp.)	4	0.333
23 Wissington (Wimb.)	4	0.289

Significant Responses

		N	P	K	N×P	N×K	P×K
Roots	(23)	+*	0	0	0	+	0
Tops ..	(20)	+*	0	0	0	0	0
Sugar %	(23)	—*	0	+*	—*	0	0
Purity %	(20)	—*	0	0	0	0	0
			Curvature				
Roots ..	..	0	0	0			
Tops ..	..	0	0	0			
Sugar %	..	—	0	0			
Purity %	..	—	0	0			

Symbols

+ = Positive, 0 = No, — = Negative: Significant Average Response

(23) = No. of centres

* = Significant differences between centres.

Mean Responses per 1 *cwt. of N,* P_2O_5 *and* K_2O.

	N		P		K	
	Average 1933-34	1935	Average 1933-34	1935	Average 1933-34	1935
Roots—tons ..	+1.07	+1.41	+0.25	+0.12	+0.12	+0.13
Tops—tons ..	+3.07	+3.20	+0.32	+0.17	+0.14	—0.01
Sugar % ..	—0.68	—0.79	0.00	0.00	+0.24	+0.20
Total Sugar ..	+2.3	+3.4	+0.9	+0.4	+0.9	+0.8
Plant number ..	+0.61	+0.35	+0.65	—0.03	+0.43	+0.07
Purity % ..	—0.9	—0.8	+0.7	+0.1	0.0	+0.2

Main Effects and First Order Interactions

ALLSCOTT 1

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed) : tons per acre ($\pm$0.727. *Means :* $\pm$*0.420*)										
N_0	7.40	9.06	7.72	7.93	7.14	9.11	*8.06*	K_0	6.87	7.07	8.91
N_1	7.16	7.05	9.04	7.87	7.44	7.95	*7.75*	K_1	6.94	8.19	7.36
N_2	7.01	7.55	8.08	7.05	7.91	7.67	*7.55*	K_2	7.76	8.41	8.56
Mean ..	*7.19*	*7.89*	*8.28*	*7.62*	*7.50*	*8.24*	*7.79*				
	TOPS : tons per acre ($\pm$0.733. *Means :* $\pm$*0.423*)										
N_0	7.06	7.42	7.30	6.86	7.50	7.39	*7.26*	K_0	6.63	7.34	7.86
N_1	7.06	7.26	9.09	7.74	7.74	7.93	*7.80*	K_1	7.46	7.97	8.45
N_2	7.30	8.17	8.65	7.22	8.65	8.25	*8.04*	K_2	7.34	7.54	8.73
Mean ..	*7.14*	*7.62*	*8.34*	*7.28*	*7.96*	*7.87*	*7.70*				
	SUGAR PERCENTAGE : ($\pm$0.315. *Means :* $\pm$*0.182*)										
N_0	15.77	16.43	16.53	16.47	16.10	16.17	*16.24*	K_0	16.13	15.70	16.10
N_1	16.10	15.77	15.77	15.33	16.20	16.10	*15.88*	K_1	16.23	15.97	15.90
N_2	15.93	15.73	16.00	16.13	15.80	15.73	*15.89*	K_2	15.43	16.27	16.30
Mean ..	*15.93*	*15.98*	*16.10*	*15.98*	*16.03*	*16.00*	*16.00*				
	TOTAL SUGAR : cwt. per acre										
N_0	23.3	29.8	25.6	26.1	23.1	29.4	*26.2*	K_0	22.4	22.3	28.6
N_1	23.1	22.3	28.4	24.2	24.1	25.6	*24.6*	K_1	22.6	26.2	23.4
N_2	22.4	23.7	25.9	22.8	25.0	24.2	*24.0*	K_2	23.9	27.4	27.9
Mean ..	*22.9*	*25.3*	*26.6*	*24.4*	*24.1*	*26.4*	*25.0*				
	PLANT NUMBER : thousands per acre										
N_0	29.3	31.5	30.8	29.7	28.2	33.8	*30.5*	K_0	31.3	29.4	27.0
N_1	30.4	31.2	34.1	34.3	32.8	28.7	*31.9*	K_1	27.2	27.9	33.5
N_2	27.5	25.8	29.7	23.7	27.6	31.7	*27.7*	K_2	28.7	31.3	34.2
Mean ..	*29.1*	*29.5*	*31.5*	*29.4*	*29.5*	*31.4*	*30.0*				
	PERCENTAGE PURITY : ($\pm$0.984. *Means :* $\pm$*0.568*)										
N_0	87.8	87.6	87.9	88.8	87.5	87.0	*87.8*	K_0	87.8	85.9	87.6
N_1	87.9	87.0	87.4	85.9	87.4	89.0	*87.4*	K_1	86.7	87.3	86.8
N_2	85.2	87.1	86.2	86.7	85.9	85.9	*86.2*	K_2	86.5	88.4	87.1
Mean ..	*87.0*	*87.2*	*87.2*	*87.1*	*86.9*	*87.3*	*87.1*				

BARDNEY (*Meth.*) 2

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed) : tons per acre ($\pm$0.204. *Means* : $\pm$*0.118*)										
N_0	8.88	8.78	9.38	9.09	9.02	8.93	*9.01*	K_0	9.41	9.22	9.36
N_1	9.58	9.38	9.18	9.60	9.26	9.29	*9.38*	K_1	9.36	9.24	9.33
N_2	9.74	9.86	9.42	9.31	9.66	10.06	*9.67*	K_2	9.43	9.56	9.30
Mean ..	*9.40*	*9.34*	*9.33*	*9.33*	*9.31*	*9.43*	*9.36*				
	TOPS : tons per acre ($\pm$0.292. *Means* : $\pm$*0.168*)										
N_0	5.74	5.83	6.22	5.87	6.08	5.84	*5.93*	K_0	7.00	8.24	7.74
N_1	7.03	7.35	7.14	7.52	7.25	6.75	*7.17*	K_1	7.12	7.42	7.47
N_2	8.49	9.76	8.91	9.59	8.68	8.89	*9.05*	K_2	7.14	7.28	7.09
Mean ..	*7.09*	*7.81*	*7.43*	*7.66*	*7.34*	*7.17*	*7.38*				
	SUGAR PERCENTAGE : ($\pm$0.141. *Means* : $\pm$*0.0814*)										
N_0	17.63	17.13	17.40	17.07	17.53	17.57	*17.39*	K_0	16.67	16.13	16.57
N_1	17.00	16.73	17.13	16.63	16.83	17.40	*16.95*	K_1	17.03	16.60	16.97
N_2	16.47	15.73	16.07	15.67	16.23	16.37	*16.09*	K_2	17.40	16.87	17.07
Mean ..	*17.03*	*16.53*	*16.87*	*16.46*	*16.87*	*17.11*	*16.81*				
	TOTAL SUGAR : cwt. per acre										
N_0	31.3	30.1	32.6	31.0	31.6	31.4	*31.3*	K_0	31.3	29.7	31.1
N_1	32.6	31.4	31.5	31.9	31.2	32.3	*31.8*	K_1	31.9	30.6	31.6
N_2	32.1	31.0	30.3	29.2	31.3	32.9	*31.1*	K_2	32.7	32.2	31.7
Mean ..	*31.9*	*28.3*	*31.5*	*30.7*	*31.4*	*32.2*	*31.4*				
	PLANT NUMBER : thousands per acre										
N_0	28.6	28.2	27.4	27.5	28.6	28.1	*28.1*	K_0	27.8	28.1	27.8
N_1	27.6	27.6	27.1	28.6	27.2	26.5	*27.4*	K_1	27.5	28.5	27.0
N_2	27.3	28.1	27.7	27.6	27.2	28.2	*27.7*	K_2	28.2	27.3	27.4
Mean ..	*27.8*	*28.0*	*27.4*	*27.9*	*27.7*	*27.6*	*27.7*				
	PERCENTAGE PURITY : ($\pm$0.674. *Means* : $\pm$*0.389*)										
N_0	87.4	87.0	88.1	87.2	88.0	87.3	*87.5*	K_0	87.4	86.4	87.7
N_1	87.6	87.1	87.2	87.7	87.0	87.2	*87.3*	K_1	88.2	86.5	86.7
N_2	87.0	86.7	85.8	86.6	86.4	86.5	*86.5*	K_2	86.4	88.0	86.6
Mean ..	*87.5*	*87.0*	*87.0*	*87.2*	*87.1*	*87.0*	*87.1*				

BARDNEY (Horn.) 3

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed): tons per acre (±0.420. *Means :* ±*0.242*)										
N_0	11.56	10.77	10.08	10.03	11.33	11.05	*10.80*	K_0	11.04	11.46	10.73
N_1	11.24	11.85	10.16	11.40	10.83	11.02	*11.08*	K_1	11.32	11.84	10.52
N_2	10.65	12.01	11.24	11.79	11.53	10.58	*11.30*	K_2	11.09	11.32	10.23
Mean ..	*11.15*	*11.54*	*10.49*	*11.08*	*11.23*	*10.88*	*11.06*				
	TOPS: tons per acre (±0.612. *Means :* ±*0.353*)										
N_0	8.75	6.97	8.43	7.75	8.10	8.30	*8.05*	K_0	10.13	9.60	8.66
N_1	9.93	10.09	8.22	9.55	9.52	9.17	*9.41*	K_1	10.03	9.61	9.44
N_2	10.68	10.97	11.66	11.09	11.46	10.76	*11.10*	K_2	9.20	8.82	10.21
Mean ..	*9.79*	*9.34*	*9.44*	*9.46*	*9.69*	*9.41*	*9.52*				
	SUGAR PERCENTAGE: (±0.189. *Means :* ±*0.109*)										
N_0	16.47	17.23	16.97	16.87	16.63	17.17	*16.89*	K_0	16.53	16.50	16.60
N_1	16.70	16.63	16.73	16.77	16.60	16.70	*16.69*	K_1	16.37	16.73	16.43
N_2	16.40	16.10	16.07	16.00	16.30	16.27	*16.19*	K_2	16.67	16.73	16.73
Mean ..	*16.52*	*16.65*	*16.59*	*16.55*	*16.51*	*16.71*	*16.59*				
	TOTAL SUGAR: cwt. per acre										
N_0	38.0	37.1	34.2	33.8	37.6	37.9	*36.4*	K_0	36.5	37.7	35.6
N_1	37.6	39.4	34.0	38.2	35.9	36.8	*37.0*	K_1	37.0	39.6	34.5
N_2	35.0	38.6	36.1	37.7	37.6	34.4	*36.6*	K_2	37.1	37.9	34.2
Mean ..	*36.9*	*38.4*	*34.8*	*36.6*	*37.0*	*36.4*	*36.7*				
	PLANT NUMBER: thousands per acre										
N_0	26.0	24.9	23.6	23.8	24.8	25.9	*24.8*	K_0	24.9	25.6	24.3
N_1	27.4	26.5	23.8	25.7	25.9	26.1	*25.9*	K_1	25.3	25.6	24.2
N_2	22.6	25.4	24.6	25.3	24.4	22.9	*24.2*	K_2	25.8	25.7	23.5
Mean ..	*25.3*	*25.6*	*24.0*	*24.9*	*25.0*	*25.0*	*25.0*				
	PERCENTAGE PURITY: (±0.555. *Means :* ±*0.320*)										
N_0	86.4	86.8	86.5	86.7	86.3	86.7	*86.7*	K_0	86.1	86.7	86.6
N_1	86.1	87.4	86.0	86.3	85.9	87.4	*86.5*	K_1	86.2	87.0	85.8
N_2	87.0	86.9	86.5	86.4	86.9	87.2	*86.8*	K_2	87.2	87.5	86.5
Mean ..	*86.5*	*87.1*	*86.3*	*86.5*	*86.3*	*87.1*	*86.6*				

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BRIGG (*Caistor*) 4

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed) : tons per acre ($\pm$0.483. *Means :* $\pm$***0.279***)										
N_0	8.29	8.08	8.58	7.97	9.05	7.92	*8.32*	K_0	9.89	10.08	10.63
N_1	10.42	11.39	10.81	11.12	10.82	10.69	*10.87*	K_1	10.36	10.45	10.82
N_2	11.45	11.84	12.21	11.51	11.79	12.21	*11.83*	K_2	9.91	10.76	10.15
Mean ..	*10.05*	*10.43*	*10.53*	*10.20*	*10.55*	*10.27*	*10.34*				
	TOPS : tons per acre ($\pm$0.394. *Means :* $\pm$*0.227*)										
N_0	4.87	4.26	4.71	4.60	4.80	4.43	*4.61*	K_0	7.27	6.85	7.38
N_1	6.76	6.63	6.76	7.18	6.80	6.17	*6.72*	K_1	7.02	6.39	7.25
N_2	10.21	9.33	9.05	9.72	9.06	9.82	*9.53*	K_2	7.56	6.98	5.78
Mean ..	*7.28*	*6.74*	*6.80*	*7.17*	*6.90*	*6.77*	*6.95*				
	SUGAR PERCENTAGE : ($\pm$0.170. *Means:* $\pm$*0.0982*)										
N_0	17.47	17.60	17.70	17.33	17.60	17.83	*17.59*	K_0	16.87	17.37	17.10
N_1	17.37	17.70	17.60	17.30	17.67	17.70	*17.56*	K_1	17.33	17.73	17.40
N_2	16.57	17.27	17.10	16.70	17.20	17.03	*16.98*	K_2	17.20	17.47	17.90
Mean ..	*17.14*	*17.52*	*17.47*	*17.11*	*17.49*	*17.52*	*17.38*				
	TOTAL SUGAR : cwt. per acre										
N_0	29.0	28.4	30.3	27.6	31.8	28.3	*29.2*	K_0	33.4	34.9	36.3
N_1	36.2	40.3	38.0	38.4	38.2	37.8	*38.2*	K_1	35.8	37.2	37.5
N_2	37.9	40.8	41.8	38.5	40.4	41.6	*40.2*	K_2	33.9	37.5	36.3
Mean ..	*34.4*	*36.5*	*36.7*	*34.9*	*36.8*	*35.9*	*35.9*				
	PLANT NUMBER : thousands per acre										
N_0	24.4	23.0	24.3	22.7	25.4	23.5	*23.9*	K_0	25.2	24.4	25.5
N_1	25.3	26.1	25.3	25.9	26.0	24.8	*25.6*	K_1	25.6	26.1	26.4
N_2	26.7	26.5	26.8	26.5	26.7	26.9	*26.7*	K_2	25.6	25.1	24.5
Mean ..	*25.5*	*25.2*	*25.5*	*25.0*	*26.0*	*25.1*	*25.4*				
	PERCENTAGE PURITY : ($\pm$0.259. *Means :* $\pm$*0.150*)										
N_0	89.1	90.1	90.2	89.4	89.7	90.2	*89.8*	K_0	88.9	89.7	89.3
N_1	89.3	90.2	89.6	89.7	89.7	89.8	*89.7*	K_1	89.0	89.7	89.7
N_2	89.0	88.9	89.2	88.8	89.0	89.3	*89.0*	K_2	89.6	89.8	90.0
Mean ..	*89.2*	*89.7*	*89.7*	*89.3*	*89.5*	*89.8*	*89.5*				

BRIGG (*Scotton*) 5

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed): tons per acre (±0.457. *Means : ±0.264*)										
N_0	7.56	7.77	8.28	7.85	8.54	7.23	*7.87*	K_0	8.71	10.04	9.81
N_1	8.93	10.08	9.66	9.47	9.63	9.57	*9.56*	K_1	9.52	9.35	10.11
N_2	10.42	11.25	10.72	11.24	10.81	10.33	*10.80*	K_2	8.68	9.71	8.75
Mean ..	*8.97*	*9.70*	*9.56*	*9.52*	*9.66*	*9.04*	*9.41*				
	TOPS: tons per acre (±0.311. *Means : ±0.180*)										
N_0	5.10	5.27	5.22	4.82	5.68	5.09	*5.20*	K_0	7.27	7.85	7.23
N_1	7.15	7.73	7.59	7.11	7.89	7.48	*7.49*	K_1	7.68	7.69	8.23
N_2	9.85	10.27	9.64	10.42	10.03	9.31	*9.92*	K_2	7.15	7.74	6.99
Mean ..	*7.37*	*7.76*	*7.48*	*7.45*	*7.87*	*7.29*	*7.54*				
	SUGAR PERCENTAGE: (±0.225. *Means : ±0.130*)										
N_0	16.63	16.87	16.93	17.00	16.73	16.70	*16.81*	K_0	16.63	16.80	16.60
N_1	16.70	16.67	16.73	16.67	16.87	16.57	*16.70*	K_1	16.63	16.27	16.60
N_2	16.43	16.40	15.93	16.37	15.90	16.50	*16.25*	K_2	16.50	16.87	16.40
Mean ..	*16.59*	*16.65*	*16.53*	*16.68*	*16.50*	*16.59*	*16.59*				
	TOTAL SUGAR: cwt. per acre										
N_0	25.2	26.2	28.0	26.7	28.6	24.1	*26.5*	K_0	28.9	33.6	32.5
N_1	29.9	33.7	32.3	31.6	32.5	31.7	*32.0*	K_1	31.7	30.4	33.4
N_2	34.2	36.9	34.2	36.8	34.4	34.2	*35.1*	K_2	28.7	32.8	28.6
Mean ..	*29.8*	*32.3*	*31.5*	*31.7*	*31.8*	*30.0*	*31.2*				
	PLANT NUMBER: thousands per acre										
N_0	33.4	33.1	31.1	33.0	32.9	31.7	*32.5*	K_0	33.5	34.5	32.6
N_1	35.0	33.7	32.6	33.0	34.0	34.3	*33.8*	K_1	34.0	34.7	33.9
N_2	33.6	36.2	35.0	34.6	35.8	34.4	*34.9*	K_2	34.5	33.8	32.1
Mean ..	*34.0*	*34.3*	*32.9*	*33.5*	*34.2*	*33.5*	*33.7*				
	PERCENTAGE PURITY: (±0.507. *Means : ±0.293*)										
N_0	87.9	86.9	87.3	87.8	86.7	87.6	*87.4*	K_0	86.8	86.9	86.7
N_1	86.8	87.6	87.7	87.1	87.4	87.7	*87.4*	K_1	87.2	86.0	87.0
N_2	86.6	85.8	86.1	85.5	86.2	86.9	*86.2*	K_2	87.3	87.5	87.4
Mean ..	*87.1*	*86.8*	*87.0*	*86.8*	*86.8*	*87.4*	*87.0*				

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BURY ST. EDMUNDS 6

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed): tons per acre (±0.414. *Means :* ±*0.239*)										
N_0	8.77	8.77	8.85	8.89	8.44	9.06	*8.80*	K_0	9.18	9.88	9.02
N_1	8.48	9.06	9.68	9.31	8.81	9.10	*9.07*	K_1	8.61	9.02	9.51
N_2	9.80	10.21	9.80	9.88	9.88	10.05	*9.94*	K_2	9.26	9.14	9.80
Mean ..	*9.02*	*9.35*	*9.44*	*9.36*	*9.05*	*9.40*	*9.27*				
	TOPS: tons per acre (±0.374. *Means :* ±*0.216*)										
N_0	5.94	5.99	5.91	5.75	6.06	6.03	*5.95*	K_0	6.97	7.02	6.97
N_1	7.42	7.14	7.63	6.97	8.06	7.16	*7.40*	K_1	7.07	7.87	7.28
N_2	8.55	8.91	7.89	8.25	8.10	9.00	*8.45*	K_2	7.87	7.14	7.19
Mean ..	*7.30*	*7.34*	*7.15*	*6.99*	*7.41*	*7.40*	*7.26*				
	SUGAR PERCENTAGE: (±0.201. *Means :* ±*0.116*)										
N_0	17.30	17.37	17.87	17.60	17.50	17.43	*17.51*	K_0	17.07	16.90	17.70
N_1	17.33	17.20	17.33	17.33	17.27	17.27	*17.29*	K_1	17.10	17.07	17.20
N_2	16.53	16.53	17.33	16.73	16.60	17.07	*16.80*	K_2	17.00	17.13	17.63
Mean ..	*17.06*	*17.03*	*17.51*	*17.22*	*17.12*	*17.26*	*17.20*				
	TOTAL SUGAR: cwt. per acre										
N_0	30.3	30.5	31.6	31.3	29.6	31.6	*30.8*	K_0	31.3	33.3	31.9
N_1	29.4	31.1	33.5	32.2	30.4	31.4	*31.3*	K_1	29.4	30.7	32.7
N_2	32.4	33.8	34.0	33.0	32.8	34.3	*33.4*	K_2	31.5	31.3	34.5
Mean ..	*30.7*	*31.8*	*33.0*	*32.2*	*30.9*	*32.4*	*31.8*				
	PLANT NUMBER: thousands per acre										
N_0	25.5	25.0	23.9	25.7	23.8	24.8	*24.8*	K_0	26.0	26.8	25.1
N_1	25.4	25.5	27.8	25.5	25.8	27.4	*26.2*	K_1	26.3	25.2	25.1
N_2	29.2	26.6	26.1	26.9	27.0	27.9	*27.3*	K_2	27.7	25.1	27.4
Mean ..	*26.7*	*25.7*	*25.9*	*26.0*	*25.5*	*26.7*	*26.1*				
	PERCENTAGE PURITY: (±0.424. *Means :* ±*0.245*)										
N_0	90.6	91.7	91.1	91.7	91.0	90.7	*91.1*	K_0	89.9	91.0	90.9
N_1	90.8	90.4	90.3	90.4	90.6	90.5	*90.5*	K_1	90.9	90.0	90.4
N_2	89.6	89.5	90.1	89.8	89.7	89.7	*89.7*	K_2	90.2	90.6	90.1
Mean ..	*90.3*	*90.5*	*90.5*	*90.6*	*90.4*	*90.3*	*90.4*				

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CANTLEY 7

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed) : tons per acre ($\pm$0.521. *Means :* $\pm$*0.301*)										
N_0	11.62	12.95	12.48	12.17	12.64	12.25	*12.35*	K_0	12.48	12.41	12.48
N_1	12.72	12.80	12.80	12.80	13.03	12.49	*12.77*	K_1	13.34	12.64	12.80
N_2	13.42	12.72	13.42	12.41	13.11	14.05	*13.19*	K_2	11.94	13.42	13.42
Mean ..	*12.59*	*12.82*	*12.90*	*12.46*	*12.93*	*12.93*	*12.77*				
	TOPS : tons per acre ($\pm$0.518. *Means :* $\pm$*0.299*)										
N_0	8.33	8.26	7.43	7.97	8.40	7.64	*8.00*	K_0	9.36	8.85	9.63
N_1	8.56	8.38	9.08	9.16	9.22	7.64	*8.67*	K_1	9.27	9.81	8.96
N_2	10.22	10.93	10.97	10.71	10.43	10.97	*10.71*	K_2	8.47	8.90	8.89
Mean ..	*9.04*	*9.19*	*9.16*	*9.28*	*9.35*	*8.75*	*9.13*				
	SUGAR PERCENTAGE : ($\pm$0.208. *Means :* $\pm$*0.120*)										
N_0	17.90	17.57	17.47	17.37	18.00	17.57	*17.65*	K_0	17.70	16.93	17.00
N_1	17.73	17.47	17.33	17.33	17.60	17.60	*17.51*	K_1	17.50	17.93	17.23
N_2	17.30	16.93	16.67	16.93	17.07	16.93	*16.97*	K_2	17.77	17.10	17.23
Mean ..	*17.64*	*17.32*	*17.16*	*17.21*	*17.55*	*17.37*	*17.38*				
	TOTAL SUGAR : cwt. per acre										
N_0	41.6	45.5	43.7	42.3	45.5	43.0	*43.6*	K_0	44.2	42.0	42.5
N_1	45.1	44.7	44.4	44.4	45.7	43.9	*44.7*	K_1	46.6	45.4	44.1
N_2	46.5	43.1	44.8	42.0	44.8	47.6	*44.8*	K_2	42.3	45.9	46.2
Mean ..	*44.4*	*44.4*	*44.3*	*42.9*	*45.4*	*44.8*	*44.4*				
	PLANT NUMBER : thousands per acre										
N_0	32.7	32.7	31.3	31.5	32.7	32.4	*32.2*	K_0	32.6	31.7	31.0
N_1	32.3	31.0	25.0	30.5	27.3	30.4	*29.4*	K_1	34.0	31.1	27.8
N_2	34.3	31.8	33.2	33.2	32.9	33.2	*33.1*	K_2	32.7	32.7	30.7
Mean ..	*33.1*	*31.8*	*29.8*	*31.8*	*31.0*	*32.0*	*31.6*				
	PERCENTAGE PURITY : ($\pm$1.49. *Means :* $\pm$*0.860*)										
N_0	93.8	94.3	92.3	91.7	94.5	94.2	*93.5*	K_0	92.9	90.3	93.0
N_1	92.7	92.7	96.1	93.2	93.0	95.4	*93.8*	K_1	92.4	94.1	93.2
N_2	94.5	90.8	92.6	91.4	92.2	94.4	*92.6*	K_2	95.7	93.4	94.8
Mean ..	*93.7*	*92.6*	*93.7*	*92.1*	*93.2*	*94.6*	*93.3*				

COLWICK (*Cast.*) *8.*

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed) : tons per acre (±0.727. *Means : ±0.420*)										
N_0	11.16	12.25	10.76	11.28	11.77	11.12	*11.39*	K_0	10.80	13.38	11.45
N_1	12.73	12.86	11.85	11.77	13.30	12.37	*12.48*	K_1	12.77	13.90	11.97
N_2	13.58	13.66	13.10	12.57	13.58	14.19	*13.45*	K_2	13.90	11.47	12.29
Mean ..	*12.49*	*12.92*	*11.90*	*11.87*	*12.88*	*12.56*	*12.44*				
	TOPS : tons per acre (±0.482. *Means : ±0.278*)										
N_0	5.88	6.47	5.82	5.95	5.84	6.39	*6.06*	K_0	7.58	8.33	6.55
N_1	8.45	7.97	7.90	7.01	8.59	8.72	*8.11*	K_1	8.20	8.35	7.94
N_2	11.00	10.18	9.09	9.49	10.06	10.71	*10.09*	K_2	9.56	7.94	8.32
Mean ..	*8.45*	*8.21*	*7.60*	*7.48*	*8.16*	*8.61*	*8.08*				
	SUGAR PERCENTAGE : (±0.341. *Means : ±0.197*)										
N_0	17.93	17.83	18.23	17.90	18.33	17.77	*18.00*	K_0	17.20	17.67	17.10
N_1	17.57	17.40	17.33	17.47	17.73	17.10	*17.43*	K_1	17.87	17.80	17.70
N_2	16.87	17.03	16.83	16.60	17.30	16.83	*16.91*	K_2	17.30	16.80	17.60
Mean ..	*17.46*	*17.42*	*17.47*	*17.32*	*17.79*	*17.23*	*17.45*				
	TOTAL SUGAR : cwt. per acre										
N_0	40.1	43.8	39.2	40.5	43.1	39.5	*41.0*	K_0	37.0	47.3	39.1
N_1	44.8	44.9	41.1	41.1	47.1	42.5	*43.6*	K_1	45.6	49.4	42.3
N_2	45.8	46.6	44.2	41.7	47.0	47.8	*45.5*	K_2	48.1	38.6	43.1
Mean ..	*43.6*	*45.1*	*41.5*	*41.1*	*45.8*	*43.3*	*43.4*				
	PLANT NUMBER : thousands per acre										
N_0	33.4	32.8	33.5	33.3	32.8	33.7	*33.3*	K_0	33.7	32.9	32.2
N_1	34.2	33.6	33.1	33.4	33.8	33.6	*33.6*	K_1	33.1	32.9	33.3
N_2	33.0	32.7	32.1	32.1	32.7	33.0	*32.6*	K_2	33.8	33.3	33.3
Mean ..	*33.5*	*33.0*	*32.9*	*32.9*	*33.1*	*33.5*	*33.2*				
	PERCENTAGE PURITY : (±0.676. *Means : ±0.390*)										
N_0	87.3	87.8	87.3	87.1	88.0	87.3	*87.5*	K_0	86.5	88.3	87.5
N_1	87.7	87.9	87.9	87.9	87.1	88.4	*87.8*	K_1	87.0	88.2	87.3
N_2	86.7	87.7	88.2	87.3	87.3	88.0	*87.5*	K_2	88.2	86.9	88.6
Mean ..	*87.2*	*87.8*	*87.8*	*87.4*	*87.5*	*87.9*	*87.6*				

COLWICK (Dent.) 9

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed): tons per acre (±0.390. *Means :* ± *0.225*)										
N_0	9.41	9.94	9.20	9.90	9.03	9.61	*9.52*	K_0	9.94	9.78	9.61
N_1	9.94	9.53	9.28	9.65	10.02	9.07	*9.58*	K_1	9.49	10.15	9.20
N_2	9.82	9.86	9.94	9.77	9.78	10.07	*9.87*	K_2	9.74	9.40	9.61
Mean ..	*9.72*	*9.78*	*9.47*	*9.78*	*9.61*	*9.58*	*9.66*				
	TOPS: tons per acre (±0.466. *Means :* ±*0.269*)										
N_0	7.42	7.36	7.58	7.61	7.05	7.70	*7.45*	K_0	7.94	7.84	8.30
N_1	8.30	8.22	8.47	7.90	9.30	7.79	*8.33*	K_1	7.81	8.72	9.19
N_2	8.33	9.23	10.05	8.58	9.36	9.67	*9.20*	K_2	8.30	8.26	8.61
Mean ..	*8.02*	*8.27*	*8.70*	*8.03*	*8.57*	*8.39*	*8.33*				
	SUGAR PERCENTAGE: (±0.231. *Means :* ±*0.133*)										
N_0	17.37	17.17	17.10	17.03	17.47	17.13	*17.21*	K_0	16.73	16.90	16.73
N_1	17.13	16.77	17.20	16.77	17.13	17.20	*17.03*	K_1	17.27	17.20	17.10
N_2	17.03	16.90	16.53	16.57	16.97	16.93	*16.82*	K_2	17.53	16.70	17.00
Mean ..	*17.18*	*16.95*	*16.94*	*16.79*	*17.19*	*17.08*	*17.02*				
	TOTAL SUGAR: cwt. per acre										
N_0	32.7	34.1	31.5	33.7	31.6	32.9	*32.7*	K_0	33.3	33.0	32.1
N_1	34.0	31.9	31.9	32.3	34.3	31.2	*32.6*	K_1	32.7	34.8	31.5
N_2	33.4	33.3	32.8	32.3	33.2	34.1	*33.2*	K_2	34.1	31.5	32.6
Mean ..	*33.4*	*33.1*	*32.1*	*32.8*	*33.0*	*32.7*	*32.8*				
	PLANT NUMBER: thousands per acre										
N_0	26.0	27.0	24.3	25.3	26.8	25.2	*25.8*	K_0	25.3	26.5	25.0
N_1	27.0	24.9	26.2	26.2	26.1	25.9	*26.1*	K_1	26.3	26.7	25.7
N_2	25.3	25.8	25.8	25.3	25.9	25.7	*25.6*	K_2	26.6	24.5	25.7
Mean ..	*26.1*	*25.9*	*25.5*	*25.6*	*26.2*	*25.6*	*25.8*				
	PERCENTAGE PURITY: (±0.308. *Means :* ±*0.178*)										
N_0	85.9	86.2	85.7	85.3	86.3	86.3	*86.0*	K_0	85.6	86.2	86.5
N_1	86.4	86.6	86.6	86.6	86.4	86.6	*86.5*	K_1	86.3	86.1	86.3
N_2	85.5	86.3	86.7	86.5	85.6	86.3	*86.1*	K_2	86.2	86.9	86.1
Mean ..	*86.0*	*86.4*	*86.3*	*86.1*	*86.2*	*86.4*	*86.2*				

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	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed): tons per acre ($\pm$0.589). *Means*: $\pm$*0.340*)										
N_0	11.95	11.33	11.13	11.06	11.01	12.34	*11.47*	K_0	11.39	10.59	11.81
N_1	11.79	11.87	12.36	11.77	11.45	12.81	*12.01*	K_1	11.67	11.99	11.03
N_2	12.29	11.43	11.58	10.96	12.23	12.11	*11.77*	K_2	12.98	12.05	12.23
Mean ..	*12.01*	*11.54*	*11.69*	*11.26*	*11.56*	*12.42*	*11.75*				
	TOPS: tons per acre ($\pm$2.85. *Means*: $\pm$*1.64*)										
N_0	21.18	22.00	21.55	22.47	20.18	22.08	*21.58*	K_0	22.15	23.28	17.18
N_1	21.14	22.01	21.85	22.51	20.87	21.61	*21.67*	K_1	14.52	20.00	21.40
N_2	16.27	22.47	15.20	17.63	14.85	21.46	*17.98*	K_2	21.92	23.21	20.02
Mean ..	*19.53*	*22.16*	*19.53*	*20.87*	*18.64*	*21.72*	*20.41*				
	SUGAR PERCENTAGE: ($\pm$0.500. *Means*: $\pm$*0.289*)										
N_0	14.20	14.77	14.93	13.63	15.43	14.83	*14.63*	K_0	14.47	13.97	13.13
N_1	15.30	14.90	14.87	14.43	15.40	15.23	*15.02*	K_1	14.70	14.57	15.27
N_2	14.73	13.77	14.20	13.50	13.70	15.50	*14.23*	K_2	15.07	14.90	15.60
Mean ..	*14.74*	*14.48*	*14.67*	*13.85*	*14.84*	*15.19*	*14.63*				
	TOTAL SUGAR: cwt. per acre										
N_0	34.0	33.5	33.3	30.1	34.0	36.6	*33.6*	K_0	32.9	29.6	31.2
N_1	36.0	35.6	36.6	33.8	35.4	39.0	*36.1*	K_1	34.2	34.9	33.7
N_2	36.2	31.3	33.3	29.8	33.4	37.6	*33.6*	K_2	39.1	35.9	38.3
Mean ..	*35.4*	*33.5*	*34.4*	*31.2*	*34.3*	*37.7*	*34.4*				
	PLANT NUMBER: thousands per acre										
N_0	31.9	33.3	36.3	31.4	35.7	34.5	*33.8*	K_0	30.4	31.6	29.9
N_1	35.3	31.1	27.3	29.5	32.2	32.4	*31.2*	K_1	29.0	33.5	32.0
N_2	24.6	34.9	26.2	31.0	26.6	28.1	*28.6*	K_2	32.4	34.5	28.0
Mean ..	*30.6*	*33.1*	*30.0*	*30.6*	*31.5*	*31.6*	*31.2*				
	PERCENTAGE PURITY: ($\pm$0.760. *Means*: $\pm$*0.439*)										
N_0	85.7	84.7	86.9	85.7	86.4	85.2	*85.8*	K_0	87.0	85.7	83.9
N_1	86.3	86.1	85.0	85.2	85.9	86.3	*85.8*	K_1	85.7	84.9	86.6
N_2	85.9	86.2	85.0	85.7	84.9	86.4	*85.7*	K_2	85.1	86.3	86.4
Mean ..	*86.0*	*85.7*	*85.6*	*85.5*	*85.7*	*85.9*	*85.7*				

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FELSTEAD 11

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed) : tons per acre ($\pm$0.704. *Means : $\pm$0.406*)										
N_0	10.31	8.66	9.45	9.21	9.37	9.84	*9.47*	K_0	8.66	9.37	11.33
N_1	8.90	10.16	9.29	9.60	8.66	10.08	*9.45*	K_1	9.29	10.47	8.82
N_2	9.60	10.94	11.26	10.55	10.55	10.71	*10.60*	K_2	10.86	9.92	9.84
Mean ..	*9.60*	*9.92*	*10.00*	*9.79*	*9.53*	*10.21*	*9.84*				
	TOPS : tons per acre ($\pm$0.993. *Means : $\pm$0.573*)										
N_0	2.74	3.22	4.88	4.00	4.16	2.68	*3.61*	K_0	3.06	4.04	5.18
N_1	3.45	2.24	2.82	3.53	1.86	3.15	*2.84*	K_1	3.10	4.53	2.66
N_2	3.23	5.33	3.87	4.74	4.27	3.42	*4.14*	K_2	3.26	2.26	3.72
Mean ..	*3.14*	*3.60*	*3.86*	*4.07*	*3.43*	*3.08*	*3.53*				
	SUGAR PERCENTAGE : ($\pm$0.251. *Means : $\pm$0.145*)										
N_0	17.33	17.30	17.07	17.20	17.13	17.37	*17.23*	K_0	16.27	17.07	17.10
N_1	16.70	17.30	16.73	16.43	17.17	17.13	*16.91*	K_1	17.03	17.07	16.87
N_2	16.37	16.77	17.10	16.80	16.67	16.77	*16.75*	K_2	17.10	17.23	16.93
Mean ..	*16.80*	*17.12*	*16.97*	*16.81*	*16.99*	*17.09*	*17.00*				
	TOTAL SUGAR : cwt. per acre										
N_0	35.8	30.0	32.3	31.7	32.2	34.2	*32.7*	K_0	28.3	32.0	38.8
N_1	29.9	35.2	31.1	31.8	29.7	34.6	*32.1*	K_1	31.6	35.7	29.8
N_2	31.4	36.7	38.5	35.5	35.2	35.9	*35.5*	K_2	37.2	34.1	33.3
Mean ..	*32.4*	*34.0*	*34.0*	*33.0*	*32.4*	*34.9*	*33.4*				
	PLANT NUMBER : thousands per acre										
N_0	20.4	19.2	20.3	19.9	19.4	20.9	*20.1*	K_0	18.2	20.4	23.3
N_1	19.3	20.1	21.7	20.5	20.4	20.7	*20.4*	K_1	19.9	21.7	19.6
N_2	19.8	21.7	22.5	21.9	21.3	20.8	*21.3*	K_2	21.8	18.9	21.7
Mean ..	*20.0*	*20.3*	*21.5*	*20.6*	*20.4*	*20.8*	*20.6*				
	PERCENTAGE PURITY : ($\pm$0.296. *Means : $\pm$0.171*)										
N_0	86.9	86.6	86.3	86.7	86.7	86.4	*86.6*	K_0	86.6	87.0	86.2
N_1	86.4	87.5	86.4	86.6	87.0	86.6	*86.7*	K_1	86.5	87.3	86.7
N_2	86.7	86.9	86.3	86.4	86.7	86.7	*86.7*	K_2	86.9	86.8	86.1
Mean ..	*86.7*	*87.0*	*86.3*	*86.6*	*86.8*	*86.6*	*86.6*				

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Ipswich 12

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed) : tons per acre ($\pm$0.595. *Means* : $\pm$*0.344*)										
N_0	8.35	6.71	7.68	6.90	7.68	8.17	*7.58*	K_0	8.50	7.57	7.38
N_1	9.25	8.99	8.09	8.99	9.17	8.17	*8.78*	K_1	8.20	8.17	8.47
N_2	8.28	8.09	8.20	7.57	7.98	9.02	*8.19*	K_2	9.17	8.06	8.13
Mean ..	*8.62*	*7.93*	*7.99*	*7.82*	*8.28*	*8.45*	*8.18*				
	SUGAR PERCENTAGE : ($\pm$0.428. *Means* : $\pm$*0.247*)										
N_0	17.07	17.03	16.97	17.00	16.97	17.10	*17.02*	K_0	17.00	16.90	16.93
N_1	17.37	16.87	17.03	16.77	17.17	17.33	*17.09*	K_1	17.20	16.70	16.83
N_2	17.00	16.63	16.97	17.07	16.60	16.93	*16.87*	K_2	17.23	16.93	17.20
Mean ..	*17.15*	*16.84*	*16.99*	*16.94*	*16.91*	*17.12*	*16.99*				
	TOTAL SUGAR : cwt. per acre										
N_0	28.5	23.0	26.1	23.5	26.1	27.9	*25.9*	K_0	28.9	25.6	25.1
N_1	32.1	30.4	27.7	30.3	31.5	28.4	*30.1*	K_1	28.2	27.4	28.5
N_2	28.2	26.9	27.8	25.9	26.5	30.5	*27.6*	K_2	31.6	27.3	28.0
Mean ..	*29.6*	*26.8*	*27.2*	*26.5*	*28.0*	*29.0*	*27.8*				
	PERCENTAGE PURITY : ($\pm$1.26. *Means* : $\pm$*0.727*)										
N_0	93.3	88.7	93.3	93.9	90.1	91.2	*91.7*	K_0	93.5	92.2	93.1
N_1	92.5	91.7	91.4	92.0	91.4	92.2	*91.9*	K_1	93.6	90.7	90.4
N_2	94.2	91.9	92.2	93.0	93.1	92.2	*92.8*	K_2	92.9	89.4	93.4
Mean ..	*93.4*	*90.8*	*92.3*	*92.9*	*91.6*	*91.9*	*92.1*				

Kidderminster 13

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed) : tons per acre ($\pm$0.284. *Means* : $\pm$*0.164*)										
N_0	4.62	5.21	5.01	4.58	4.81	5.45	*4.95*	K_0	4.34	4.62	5.25
N_1	4.97	5.37	5.68	4.74	5.49	5.80	*5.34*	K_1	5.21	5.52	5.29
N_2	5.68	5.68	5.60	4.89	5.72	6.35	*5.65*	K_2	5.72	6.12	5.76
Mean ..	*5.09*	*5.42*	*5.43*	*4.74*	*5.34*	*5.87*	*5.31*				
	TOPS : tons per acre : ($\pm$0.354. *Means* : $\pm$*0.204*)										
N_0	5.42	5.50	5.01	5.74	4.92	5.28	*5.31*	K_0	5.45	6.50	6.26
N_1	6.03	6.54	6.52	5.84	6.69	6.56	*6.36*	K_1	6.05	6.60	6.40
N_2	6.59	7.76	7.15	6.62	7.44	7.44	*7.17*	K_2	6.54	6.70	6.03
Mean ..	*6.01*	*6.60*	*6.23*	*6.07*	*6.35*	*6.43*	*6.28*				
	SUGAR PERCENTAGE : ($\pm$0.143. *Means* : $\pm$*0.0826*)										
N_0	16.17	16.10	16.07	15.90	16.17	16.27	*16.11*	K_0	16.00	15.67	15.77
N_1	15.77	15.63	15.80	15.73	15.67	15.80	*15.73*	K_1	15.90	15.83	15.77
N_2	15.93	15.47	15.90	15.80	15.67	15.83	*15.77*	K_2	15.97	15.70	16.23
Mean ..	*15.96*	*15.73*	*15.92*	*15.81*	*15.83*	*15.97*	*15.87*				
	TOTAL SUGAR : cwt. per acre										
N_0	14.9	16.8	16.1	14.5	15.6	17.7	*15.9*	K_0	13.9	14.5	16.5
N_1	15.7	16.7	18.0	14.9	17.2	18.3	*16.8*	K_1	16.6	17.5	16.7
N_2	18.1	17.7	17.8	15.5	18.0	20.1	*17.9*	K_2	18.2	19.2	18.7
Mean ..	*16.2*	*17.1*	*17.3*	*15.0*	*16.9*	*18.7*	*16.9*				
	PLANT NUMBER : thousands per acre										
N_0	28.1	28.7	29.3	27.6	29.0	29.6	*28.7*	K_0	28.3	25.4	28.5
N_1	28.9	28.4	29.6	28.4	28.5	30.0	*29.0*	K_1	28.3	27.4	28.8
N_2	28.3	24.8	28.7	26.2	27.1	28.6	*27.3*	K_2	28.7	29.1	30.3
Mean ..	*28.4*	*27.3*	*29.2*	*27.4*	*28.2*	*29.4*	*28.3*				
	PERCENTAGE PURITY : ($\pm$0.499. *Means* : $\pm$*0.288*)										
N_0	86.9	86.1	87.1	86.1	87.4	86.7	*86.7*	K_0	86.0	86.2	86.3
N_1	86.4	86.7	86.6	86.5	86.7	86.4	*86.6*	K_1	86.2	86.6	87.1
N_2	85.4	86.0	85.8	85.9	85.8	85.5	*85.7*	K_2	86.6	86.0	86.0
Mean ..	*86.2*	*86.3*	*86.5*	*86.2*	*86.6*	*86.2*	*86.3*				

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King's Lynn 14

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed) : tons per acre ($\pm$0.354. *Means* : $\pm$*0.204*)										
N_0	7.51	7.78	7.41	7.83	7.49	7.38	*7.56*	K_0	8.41	7.83	8.05
N_1	8.33	7.94	7.93	8.02	8.13	8.05	*8.06*	K_1	8.06	7.48	8.17
N_2	8.43	7.99	8.77	8.44	8.09	8.66	*8.40*	K_2	7.80	8.40	7.89
Mean ..	*8.09*	*7.90*	*8.04*	*8.10*	*7.90*	*8.03*	*8.01*				
	TOPS : tons per acre ($\pm$0.548. *Means* : $\pm$*0.316*)										
N_0	3.15	3.71	3.02	2.98	3.57	3.34	*3.29*	K_0	4.14	3.08	3.51
N_1	4.05	3.97	3.20	3.34	4.63	3.26	*3.74*	K_1	4.98	4.24	4.17
N_2	5.05	4.08	5.33	4.42	5.19	4.86	*4.82*	K_2	3.13	4.45	3.88
Mean ..	*4.08*	*3.92*	*3.85*	*3.58*	*4.46*	*3.82*	*3.95*				
	SUGAR PERCENTAGE ($\pm$0.584. *Means*: $\pm$*0.337*)										
N_0	19.73	20.03	20.43	20.47	19.67	20.07	*20.06*	K_0	19.77	18.33	19.50
N_1	19.87	19.87	19.40	19.17	20.10	19.87	*19.71*	K_1	19.73	19.80	18.73
N_2	19.43	18.43	17.90	17.97	18.50	19.30	*18.59*	K_2	19.53	20.20	19.50
Mean ..	*19.68*	*19.44*	*19.24*	*19.20*	*19.42*	*19.74*	*19.45*				
	TOTAL SUGAR : cwt. per acre										
N_0	29.6	31.2	30.2	32.0	29.4	29.6	*30.3*	K_0	33.2	28.6	31.3
N_1	33.0	31.7	30.8	30.8	32.7	32.0	*31.8*	K_1	31.7	29.6	30.5
N_2	32.7	29.3	31.4	30.3	29.7	33.4	*31.1*	K_2	30.5	33.9	30.6
Mean ..	*31.8*	*30.7*	*30.8*	*31.0*	*30.6*	*31.7*	*31.1*				
	PLANT NUMBER : thousands per acre										
N_0	33.1	33.5	32.0	32.6	33.1	32.9	*32.9*	K_0	32.5	31.5	33.1
N_1	33.8	32.3	31.9	32.9	32.8	32.7	*32.7*	K_1	33.9	33.6	31.9
N_2	33.2	32.5	32.9	31.7	33.6	33.3	*32.9*	K_2	33.7	33.2	31.8
Mean ..	*33.4*	*32.8*	*32.3*	*32.4*	*33.1*	*32.9*	*32.8*				
	PERCENTAGE PURITY ($\pm$1.23. *Means* : $\pm$*0.710*)										
N_0	85.4	85.8	86.5	86.0	85.4	86.3	*85.9*	K_0	86.0	84.9	84.6
N_1	86.0	86.9	84.6	85.6	85.9	86.0	*85.8*	K_1	84.8	86.6	85.5
N_2	81.8	85.4	84.5	84.0	85.7	82.1	*83.9*	K_2	82.4	86.5	85.4
Mean ..	*84.4*	*86.0*	*85.2*	*85.2*	*85.6*	*84.8*	*85.2*				

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Newark 15

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed) : tons per acre ($\pm$0.512. *Means* : $\pm$*0.296*)										
N_0	7.79	6.19	7.45	7.37	7.64	6.42	*7.14*	K_0	7.96	7.55	7.62
N_1	7.57	7.52	7.21	7.40	7.08	7.82	*7.43*	K_1	7.71	7.07	6.74
N_2	8.13	7.42	7.15	8.37	6.79	7.53	*7.56*	K_2	7.83	6.51	7.44
Mean ..	*7.83*	*7.04*	*7.27*	*7.71*	*7.17*	*7.26*	*7.38*				
	TOPS : tons per acre ($\pm$0.791. *Means* : $\pm$*0.457*)										
N_0	6.76	4.90	6.20	5.83	6.57	5.45	*5.95*	K_0	8.37	8.68	7.94
N_1	7.56	8.06	7.01	7.94	7.01	7.69	*7.55*	K_1	8.68	6.51	7.63
N_2	11.10	9.05	10.73	11.22	9.24	10.42	*10.29*	K_2	8.37	6.82	8.37
Mean ..	*8.47*	*7.34*	*7.98*	*8.33*	*7.61*	*7.85*	*7.93*				
	SUGAR PERCENTAGE ($\pm$0.171. *Means* : $\pm$*0.0987*)										
N_0	16.70	16.77	16.80	16.83	16.90	16.53	*16.75*	K_0	16.50	16.53	16.93
N_1	16.67	16.63	16.90	16.70	16.57	16.93	*16.73*	K_1	16.53	16.60	16.40
N_2	16.53	16.37	16.07	16.43	16.07	16.47	*16.32*	K_2	16.87	16.63	16.43
Mean ..	*16.63*	*16.59*	*16.59*	*16.65*	*16.51*	*16.64*	*16.60*				
	TOTAL SUGAR : cwt. per acre										
N_0	26.0	20.8	25.0	24.8	25.8	21.3	*24.0*	K_0	26.3	24.9	25.8
N_1	25.2	25.0	24.3	24.7	23.4	26.4	*24.8*	K_1	25.5	23.5	22.1
N_2	26.9	24.2	23.0	27.5	21.9	24.8	*24.7*	K_2	26.4	21.7	24.5
Mean ..	*26.1*	*23.4*	*24.1*	*25.7*	*23.7*	*24.2*	*24.5*				
	PLANT NUMBER : thousands per acre										
N_0	29.9	30.4	29.6	29.9	30.5	29.5	*30.0*	K_0	28.6	29.5	29.6
N_1	30.9	28.4	27.8	28.2	28.7	30.1	*29.0*	K_1	32.0	30.8	28.6
N_2	29.0	32.5	30.4	29.6	32.2	30.1	*30.6*	K_2	29.1	31.0	29.6
Mean ..	*29.9*	*30.5*	*29.3*	*29.2*	*30.5*	*29.9*	*29.9*				

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OAKLANDS 16

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed): tons per acre ($\pm$0.297. *Means:* $\pm$*0.171*)										
N_0	5.39	5.89	5.48	5.09	6.13	5.53	*5.59*	K_0	5.23	5.35	5.88
N_1	6.07	5.69	6.35	5.63	6.34	6.15	*6.04*	K_1	6.14	6.66	6.42
N_2	5.86	6.75	7.03	5.74	6.75	7.15	*6.55*	K_2	5.95	6.32	6.56
Mean ..	*5.77*	*6.11*	*6.29*	*5.49*	*6.41*	*6.28*	*6.06*				
	TOPS: tons per acre ($\pm$0.282. *Means:* $\pm$*0.163*)										
N_0	4.86	4.77	4.75	4.89	5.13	4.36	*4.79*	K_0	6.43	6.32	7.08
N_1	6.78	6.45	6.99	6.85	6.83	6.54	*6.74*	K_1	6.80	6.52	6.65
N_2	7.85	7.89	8.55	8.09	8.01	8.20	*8.10*	K_2	6.26	6.27	6.56
Mean ..	*6.50*	*6.37*	*6.76*	*6.61*	*6.66*	*6.37*	*6.54*				
	SUGAR PERCENTAGE: ($\pm$0.180. *Means:* $\pm$*0.104*)										
N_0	16.07	16.40	16.67	16.07	16.37	16.70	*16.38*	K_0	15.63	15.77	15.87
N_1	15.83	15.93	15.90	15.73	15.90	16.03	*15.89*	K_1	15.70	16.10	16.30
N_2	15.57	15.80	15.80	15.47	15.83	15.90	*15.73*	K_2	16.17	16.27	16.20
Mean ..	*15.83*	*16.05*	*16.12*	*15.76*	*16.03*	*16.21*	*16.00*				
	TOTAL SUGAR: cwt. per acre										
N_0	17.3	19.3	18.3	16.4	20.1	18.5	*18.3*	K_0	16.3	16.9	18.7
N_1	19.2	18.1	20.2	17.7	20.2	19.7	*19.2*	K_1	19.3	21.5	20.9
N_2	18.3	21.3	22.2	17.8	21.4	22.7	*20.6*	K_2	19.2	20.5	21.2
Mean ..	*18.3*	*19.6*	*20.3*	*17.3*	*20.6*	*20.3*	*19.4*				
	PLANT NUMBER: thousands per acre										
N_0	24.3	23.2	23.3	23.8	24.2	22.8	*23.6*	K_0	23.3	23.3	22.5
N_1	23.0	23.4	22.5	22.2	23.6	23.2	*23.0*	K_1	24.5	23.9	23.8
N_2	24.3	24.2	24.2	23.1	24.6	24.9	*24.2*	K_2	23.8	23.6	23.5
Mean ..	*23.9*	*23.6*	*23.3*	*23.0*	*24.1*	*23.6*	*23.6*				

PETERBOROUGH (THOR) 17

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed): tons per acre ($\pm$0.693. *Means:* $\pm$*0.400*)										
N_0	11.44	11.67	12.27	12.21	11.97	11.20	*11.79*	K_0	12.95	12.54	11.71
N_1	11.94	12.42	11.01	11.22	12.39	11.76	*11.79*	K_1	12.13	12.56	11.97
N_2	12.08	13.00	12.86	13.76	12.30	11.88	*12.65*	K_2	10.39	11.99	12.47
Mean ..	*11.82*	*12.36*	*12.05*	*12.40*	*12.22*	*11.61*	*12.08*				
	TOPS: tons per acre ($\pm$1.58. *Means:* $\pm$*0.912*)										
N_0	10.99	13.98	14.38	14.11	13.57	11.67	*13.12*	K_0	15.12	15.47	15.20
N_1	16.34	12.62	15.74	15.88	16.96	11.86	*14.90*	K_1	15.33	15.80	15.33
N_2	14.44	16.75	16.15	15.80	15.94	15.61	*15.78*	K_2	11.32	12.08	15.74
Mean ..	*13.92*	*14.45*	*15.42*	*15.26*	*15.49*	*13.05*	*14.60*				
	SUGAR PERCENTAGE: ($\pm$0.150. *Means:* $\pm$*0.0866*)										
N_0	16.57	16.60	16.23	16.37	16.50	16.53	*16.47*	K_0	16.47	16.33	16.43
N_1	16.50	16.33	16.57	16.53	16.33	16.53	*16.47*	K_1	16.53	16.43	16.37
N_2	16.50	16.27	16.30	16.33	16.55	16.23	*16.36*	K_2	16.57	16.43	16.30
Mean ..	*16.52*	*16.40*	*16.37*	*16.41*	*16.44*	*16.43*	*16.43*				
	TOTAL SUGAR: cwt. per acre										
N_0	37.9	38.7	39.8	39.9	39.5	37.0	*38.8*	K_0	42.6	40.9	38.4
N_1	39.4	40.6	36.5	37.1	40.5	38.9	*38.8*	K_1	40.1	41.3	39.2
N_2	39.9	42.3	41.9	44.9	40.6	38.6	*41.4*	K_2	34.4	39.4	40.6
Mean ..	*39.1*	*40.5*	*39.4*	*40.6*	*40.2*	*38.1*	*39.6*				
	PLANT NUMBER: thousands per acre										
N_0	24.7	20.3	22.6	21.6	23.0	23.0	*22.5*	K_0	23.2	24.2	22.6
N_1	23.8	26.0	24.2	24.3	25.9	23.8	*24.7*	K_1	25.0	25.3	23.4
N_2	24.1	25.0	23.3	24.1	24.7	23.6	*24.1*	K_2	24.4	21.8	24.1
Mean ..	*24.2*	*23.8*	*23.4*	*23.3*	*24.6*	*23.4*	*23.8*				
	PERCENTAGE PURITY: ($\pm$0.398. *Means:* $\pm$*0.230*)										
N_0	82.4	83.1	82.4	82.7	82.4	82.7	*82.6*	K_0	83.0	82.8	82.7
N_1	83.3	83.1	82.5	82.9	82.7	83.3	*83.0*	K_1	82.3	83.0	82.3
N_2	82.6	82.1	81.8	82.9	82.4	81.2	*82.2*	K_2	83.0	82.6	81.7
Mean ..	*82.8*	*82.8*	*82.2*	*82.8*	*82.5*	*82.4*	*82.6*				

PETERBOROUGH (TALL.) 18

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed) : tons per acre ($\pm$1.01. *Means: $\pm$0.583*)										
N_0	12.06	11.21	13.15	11.40	12.25	12.77	*12.14*	K_0	12.13	12.60	13.00
N_1	13.05	13.56	11.83	13.50	13.80	11.14	*12.81*	K_1	13.66	13.39	13.56
N_2	13.54	14.60	13.85	12.83	14.56	14.59	*13.99*	K_2	12.86	13.38	12.27
Mean ..	*12.88*	*13.12*	*12.94*	*12.58*	*13.54*	*12.83*	*12.98*				
	TOPS : tons per acre ($\pm$0.430. *Means: $\pm$0.248*)										
N_0	5.22	4.91	4.87	5.21	4.63	5.16	*5.00*	K_0	6.23	5.61	5.98
N_1	6.26	4.88	5.46	5.36	5.92	5.33	*5.53*	K_1	6.19	5.79	5.28
N_2	6.83	7.26	6.77	7.26	6.71	6.89	*6.95*	K_2	5.89	5.66	5.83
Mean ..	*6.10*	*5.69*	*5.70*	*5.94*	*5.75*	*5.79*	*5.83*				
	SUGAR PERCENTAGE : ($\pm$0.187. *Means: $\pm$0.108*)										
N_0	17.17	17.10	17.57	16.83	17.50	17.53	*17.28*	K_0	16.87	17.00	17.03
N_1	17.10	17.13	17.13	17.10	17.27	17.00	*17.12*	K_1	17.27	17.17	17.13
N_2	16.87	16.87	17.00	16.97	16.80	16.97	*16.91*	K_2	17.03	16.93	17.53
Mean ..	*17.05*	*17.03*	*17.23*	*16.97*	*17.19*	*17.16*	*17.10*				
	TOTAL SUGAR : cwt. per acre										
N_0	41.5	38.3	46.3	38.3	42.9	44.8	*42.0*	K_0	40.9	42.9	44.3
N_1	44.6	46.5	40.4	46.2	47.7	37.7	*43.8*	K_1	47.1	45.9	46.5
N_2	45.7	49.3	47.1	43.6	48.9	49.6	*47.4*	K_2	43.7	45.3	43.0
Mean ..	*43.9*	*44.7*	*44.6*	*42.7*	*46.5*	*44.0*	*44.4*				
	PLANT NUMBER : thousands per acre										
N_0	26.0	26.7	26.1	26.7	25.8	26.3	*26.3*	K_0	27.2	26.7	26.5
N_1	26.6	27.2	27.2	27.4	26.4	27.2	*27.0*	K_1	26.0	26.4	26.8
N_2	27.1	25.8	27.0	26.3	26.9	26.7	*26.6*	K_2	26.5	26.6	27.1
Mean ..	*26.6*	*26.6*	*26.8*	*26.8*	*26.4*	*26.7*	*26.6*				
	PERCENTAGE PURITY : ($\pm$1.16. *Means: $\pm$0.670*)										
N_0	87.6	87.1	90.4	86.3	89.4	89.3	*88.4*	K_0	86.5	87.8	87.7
N_1	87.2	88.8	87.4	88.5	88.2	86.7	*87.8*	K_1	88.0	88.0	87.7
N_2	86.4	86.3	87.2	87.1	86.1	86.7	*86.6*	K_2	86.7	86.4	89.5
Mean ..	*87.1*	*87.4*	*88.3*	*87.3*	*87.9*	*87.5*	*87.6*				

POPPLETON 19

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed): tons per acre ($\pm$0.820. *Means*: $\pm$*0.473*)										
N_0	9.23	8.88	11.44	9.96	10.91	8.67	*9.85*	K_0	10.57	10.15	11.42
N_1	10.95	11.00	11.21	10.88	12.62	9.66	*11.05*	K_1	11.12	10.65	11.82
N_2	11.58	10.75	11.64	11.30	10.06	12.60	*11.32*	K_2	10.07	9.82	11.04
Mean ..	*10.59*	*10.21*	*11.43*	*10.72*	*11.20*	*10.31*	*10.74*				
	TOPS: tons per acre ($\pm$1.43. *Means*: $\pm$*0.826*)										
N_0	4.99	4.46	6.90	5.14	6.88	4.33	*5.45*	K_0	6.24	6.37	7.32
N_1	7.87	7.86	8.02	6.09	10.10	7.56	*7.92*	K_1	8.04	7.82	7.29
N_2	9.31	9.02	7.98	8.70	6.17	11.44	*8.77*	K_2	7.89	7.14	8.30
Mean ..	*7.39*	*7.11*	*7.64*	*6.64*	*7.72*	*7.78*	*7.38*				
	SUGAR PERCENTAGE: ($\pm$0.244. *Means*: $\pm$*0.141*)										
N_0	18.30	18.30	17.50	18.03	18.07	18.00	*18.03*	K_0	17.77	17.50	17.60
N_1	17.23	17.33	17.67	17.67	17.30	17.27	*17.41*	K_1	17.67	17.63	17.90
N_2	17.37	17.20	17.90	17.17	17.83	17.47	*17.49*	K_2	17.47	17.70	17.57
Mean ..	*17.64*	*17.61*	*17.69*	*17.62*	*17.73*	*17.58*	*17.64*				
	TOTAL SUGAR: cwt. per acre										
N_0	33.7	32.4	40.0	35.8	39.2	31.1	*35.4*	K_0	37.5	35.4	40.2
N_1	37.7	38.1	39.6	38.5	43.6	33.4	*38.5*	K_1	39.0	37.5	42.2
N_2	40.2	36.7	41.6	38.8	35.9	44.0	*39.6*	K_2	35.1	34.6	38.8
Mean ..	*37.2*	*35.8*	*35.4*	*37.7*	*39.6*	*36.2*	*37.8*				
	PLANT NUMBER: thousands per acre										
N_0	24.7	24.8	25.7	27.0	26.0	22.2	*25.1*	K_0	29.6	26.8	29.5
N_1	27.6	26.8	28.5	29.4	29.9	23.6	*27.6*	K_1	27.1	27.1	27.6
N_2	28.1	28.0	28.1	29.5	25.8	28.9	*28.1*	K_2	23.8	25.8	25.2
Mean ..	*26.8*	*26.6*	*27.4*	*28.6*	*27.3*	*24.9*	*26.9*				
	PERCENTAGE PURITY: ($\pm$0.421. *Means*: $\pm$*0.243*)										
N_0	88.0	88.7	88.2	88.3	88.5	88.1	*88.3*	K_0	88.3	87.7	88.4
N_1	88.0	87.9	88.1	88.1	87.6	88.2	*88.0*	K_1	88.1	88.4	87.7
N_2	88.7	87.8	88.0	88.0	88.2	88.3	*88.2*	K_2	88.2	88.2	88.2
Mean ..	*88.2*	*88.1*	*88.1*	*88.1*	*88.1*	*88.2*	*88.2*				

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SELBY 20.

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed) : tons per acre ($\pm$0.439. *Means : $\pm$0.253*)										
N_0	11.37	10.42	11.52	11.60	11.05	10.66	*11.10*	K_0	12.33	12.18	11.85
N_1	12.26	12.77	12.34	12.69	12.56	12.11	*12.45*	K_1	11.57	12.04	11.87
N_2	11.83	12.72	12.49	12.06	11.86	13.12	*12.35*	K_2	11.56	11.69	12.64
Mean ..	*11.82*	*11.97*	*12.12*	*12.12*	*11.82*	*11.96*	*11.97*				
	TOPS : tons per acre ($\pm$0.699. *Means : $\pm$0.404*)										
N_0	7.29	6.45	8.27	7.40	7.13	7.48	*7.34*	K_0	9.74	8.76	9.79
N_1	10.19	9.47	8.80	9.68	9.50	9.32	*9.50*	K_1	8.63	9.08	9.84
N_2	9.71	11.25	13.14	11.24	10.92	11.93	*11.36*	K_2	8.82	9.32	10.58
Mean ..	*9.06*	*9.05*	*10.07*	*9.44*	*9.18*	*9.58*	*9.40*				
	SUGAR PERCENTAGE : ($\pm$0.221. *Means : $\pm$0.128*)										
N_0	18.43	18.97	18.80	18.77	18.70	18.73	*18.73*	K_0	18.37	18.70	18.63
N_1	18.50	18.60	18.73	18.80	18.73	18.30	*18.61*	K_1	18.50	18.30	18.83
N_2	18.23	18.17	18.47	18.13	18.20	18.53	*18.29*	K_2	18.30	18.73	18.53
Mean ..	*18.39*	*18.58*	*18.66*	*18.57*	*18.54*	*18.52*	*18.54*				
	TOTAL SUGAR : cwt. per acre										
N_0	41.9	39.5	43.3	43.5	41.3	39.9	*41.6*	K_0	45.3	45.6	44.1
N_1	45.3	47.5	46.3	47.8	47.0	44.3	*46.4*	K_1	42.8	44.0	44.7
N_2	43.2	46.2	46.2	43.7	43.2	48.6	*45.2*	K_2	42.3	43.7	46.9
Mean ..	*43.5*	*44.4*	*45.2*	*45.0*	*43.8*	*44.3*	*44.4*				
	PLANT NUMBER : thousands per acre										
N_0	32.1	34.3	32.1	32.5	33.4	32.6	*32.8*	K_0	33.1	35.1	31.9
N_1	34.8	33.8	35.7	34.7	35.1	34.5	*34.8*	K_1	32.1	34.5	35.9
N_2	31.3	34.4	33.8	33.0	34.0	32.6	*33.2*	K_2	33.0	32.9	33.8
Mean ..	*32.7*	*34.2*	*33.9*	*33.4*	*34.2*	*33.2*	*33.6*				
	PERCENTAGE PURITY : ($\pm$0.420. *Means : $\pm$0.242*)										
N_0	88.5	88.5	88.8	89.0	88.0	88.9	*88.6*	K_0	88.4	89.3	88.5
N_1	88.3	89.3	89.4	89.0	88.6	89.3	*89.0*	K_1	88.3	87.7	89.4
N_2	88.6	88.5	89.0	88.2	88.7	89.1	*88.7*	K_2	88.6	89.3	89.3
Mean ..	*88.4*	*88.8*	*89.1*	*88.7*	*88.5*	*89.1*	*88.8*				

TUNSTALL 21.

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed) : tons per acre ($\pm$0.308. *Means:* $\pm$*0.178*)										
N_0	4.24	4.47	4.61	4.59	4.35	4.37	*4.44*	K_0	5.34	5.68	5.36
N_1	5.03	5.17	5.15	5.19	4.90	5.27	*5.12*	K_1	5.22	5.61	5.42
N_2	6.55	7.24	6.39	6.60	7.01	6.58	*6.73*	K_2	5.25	5.59	5.37
Mean ..	*5.27*	*5.63*	*5.38*	*5.46*	*5.42*	*5.41*	*5.43*				
	TOPS : tons per acre ($\pm$0.558. *Means:* $\pm$*0.322*)										
N_0	3.23	3.30	3.06	3.27	3.15	3.18	*3.20*	K_0	4.91	4.18	5.34
N_1	4.62	4.37	4.93	4.52	4.68	4.73	*4.64*	K_1	5.34	4.73	4.90
N_2	7.06	6.79	6.89	6.65	7.15	6.94	*6.91*	K_2	4.66	5.54	4.64
Mean ..	*4.97*	*4.82*	*4.96*	*4.81*	*4.99*	*4.95*	*4.92*				
	SUGAR PERCENTAGE : ($\pm$0.200. *Means:* $\pm$*0.115*)										
N_0	16.93	16.73	16.70	16.83	16.73	16.80	*16.79*	K_0	16.17	16.43	16.07
N_1	16.17	16.80	16.50	16.33	16.23	16.90	*16.49*	K_1	16.17	16.23	16.33
N_2	15.60	15.97	15.63	15.50	15.77	15.93	*15.73*	K_2	16.37	16.83	16.43
Mean ..	*16.23*	*16.50*	*16.28*	*16.22*	*16.24*	*16.54*	*16.34*				
	TOTAL SUGAR : cwt. per acre.										
N_0	14.4	15.0	15.4	15.5	14.6	14.7	*14.9*	K_0	17.1	18.6	17.2
N_1	16.3	17.3	17.0	16.9	15.9	17.8	*16.9*	K_1	16.9	18.1	17.6
N_2	20.5	23.2	20.0	20.5	22.1	21.1	*21.2*	K_2	17.1	18.8	17.7
Mean ..	*17.0*	*18.5*	*17.5*	*17.6*	*17.5*	*17.9*	*17.7*				
	PLANT NUMBER : thousands per acre										
N_0	57.1	61.3	59.2	59.5	59.8	58.4	*59.2*	K_0	60.3	59.8	59.0
N_1	60.5	59.3	58.9	60.2	60.0	58.4	*59.6*	K_1	57.1	59.6	62.0
N_2	57.2	58.0	60.6	59.5	58.9	57.3	*58.6*	K_2	57.4	59.1	57.6
Mean ..	*58.3*	*59.5*	*59.6*	*59.7*	*59.6*	*58.0*	*59.1*				

WISSINGTON (*Crimp*) 22

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed) : tons per acre (±0.430. *Means:* ±*0.248*)										
N_0	8.36	7.80	8.40	8.13	8.46	7.97	*8.19*	K_0	8.47	8.10	8.95
N_1	8.64	8.54	8.65	8.60	8.60	8.63	*8.61*	K_1	9.19	8.48	8.05
N_2	9.76	8.72	8.67	8.78	8.67	9.69	*9.05*	K_2	9.11	8.48	8.72
Mean ..	*8.92*	*8.35*	*8.57*	*8.51*	*8.57*	*8.77*	*8.62*				
	SUGAR PERCENTAGE : (±0.210. *Means:* ±*0.121*)										
N_0	18.73	18.47	18.97	18.83	18.57	18.77	*18.72*	K_0	18.37	17.90	18.27
N_1	18.30	18.30	18.53	18.13	18.43	18.57	*18.38*	K_1	18.33	18.13	17.93
N_2	17.97	17.57	17.33	17.57	17.40	17.90	*17.62*	K_2	18.30	18.33	18.63
Mean ..	*18.33*	*18.11*	*18.28*	*18.18*	*18.13*	*18.42*	*18.24*				
	TOTAL SUGAR : cwt. per acre										
N_0	31.3	28.8	31.9	30.6	31.4	29.9	*30.6*	K_0	31.1	29.1	32.7
N_1	31.7	31.3	32.0	31.2	31.7	32.1	*31.7*	K_1	33.7	30.7	29.1
N_2	35.1	30.7	30.3	31.0	30.4	34.7	*32.0*	K_2	33.3	31.0	32.4
Mean ..	*32.7*	*30.3*	*31.4*	*30.9*	*31.2*	*32.2*	*31.4*				
	PLANT NUMBER : thousands per acre.										
N_0	28.3	28.5	29.0	27.7	28.8	29.3	*28.6*	K_0	27.6	28.5	28.0
N_1	27.4	28.5	28.4	28.1	27.4	28.8	*28.1*	K_1	27.9	27.6	28.4
N_2	28.0	27.7	28.4	28.3	27.7	28.0	*28.0*	K_2	28.1	28.6	29.3
Mean ..	*27.9*	*28.2*	*28.6*	*28.0*	*28.0*	*28.7*	*28.2*				
	PERCENTAGE PURITY (±0.719. *Means:* ±*0.415*)										
N_0	90.9	90.2	89.8	90.2	90.3	90.4	*90.3*	K_0	89.8	89.6	88.6
N_1	90.8	88.5	90.1	89.1	90.5	89.7	*89.8*	K_1	90.9	89.1	88.8
N_2	88.7	89.3	88.0	88.8	87.9	89.2	*88.7*	K_2	89.7	89.3	90.4
Mean ..	*90.1*	*89.3*	*89.3*	*89.4*	*89.6*	*89.8*	*89.6*				

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WISSINGTON (*Wimb.*) 23

	P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
	ROOTS (washed) : tons per acre ($\pm$0.872. *Means* : $\pm$*0.503*)										
N_0	8.73	8.42	7.81	8.96	7.89	8.12	*8.32*	K_0	7.77	9.16	9.78
N_1	8.13	8.14	10.63	8.59	9.62	8.70	*8.97*	K_1	9.97	7.77	9.00
N_2	9.27	8.73	9.51	9.17	9.25	9.09	*9.17*	K_2	8.38	8.36	9.17
Mean ..	*8.71*	*8.43*	*9.32*	*8.90*	*8.92*	*8.64*	*8.82*				
	SUGAR PERCENTAGE : ($\pm$0.163. *Means* : $\pm$*0.0941*)										
N_0	16.57	16.67	16.70	16.57	16.53	16.83	*16.64*	K_0	16.17	16.17	16.27
N_1	16.33	16.17	16.23	15.93	16.27	16.53	*16.24*	K_1	16.37	16.33	16.17
N_2	16.17	16.10	15.97	16.10	16.07	16.07	*16.08*	K_2	16.53	16.43	16.47
Mean ..	*16.36*	*16.31*	*16.30*	*16.20*	*16.29*	*16.48*	*16.32*				
	TOTAL SUGAR : cwt. per acre										
N_0	28.9	28.0	26.0	29.7	26.0	27.3	*27.7*	K_0	25.2	29.8	31.8
N_1	26.5	26.4	34.5	27.5	31.3	28.7	*29.2*	K_1	32.7	25.4	29.2
N_2	30.2	28.1	30.4	29.6	29.9	29.2	*29.6*	K_2	27.7	27.4	30.0
Mean ..	*28.5*	*27.5*	*30.3*	*28.9*	*29.1*	*28.4*	*28.8*				
	PLANT NUMBER : thousands per acre										
N_0	30.1	29.2	29.6	31.4	27.7	29.8	*29.6*	K_0	28.4	32.0	35.7
N_1	28.7	33.4	33.1	32.8	31.6	30.7	*31.7*	K_1	29.4	31.6	30.9
N_2	30.0	32.2	33.5	31.9	32.5	31.3	*31.9*	K_2	31.1	31.2	29.5
Mean ..	*29.6*	*31.6*	*32.0*	*32.0*	*30.6*	*30.6*	*31.1*				
	PERCENTAGE PURITY : ($\pm$0.426. *Means* : $\pm$*0.246*)										
N_0	91.4	90.7	91.3	91.0	91.3	91.1	*91.1*	K_0	90.9	89.6	91.1
N_1	90.6	89.5	90.7	89.9	90.1	90.8	*90.3*	K_1	90.2	90.1	90.5
N_2	89.4	89.9	90.6	90.7	89.4	89.8	*90.0*	K_2	90.2	90.4	91.0
Mean ..	*90.4*	*90.0*	*90.9*	*90.5*	*90.3*	*90.5*	*90.4*				

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RESPONSES TO FERTILISERS

* 5 per cent. significance. ** 1 per cent. significance.

	Station	*Mean Yield*	Linear Response (response to the double dressing) N	P	K	St. error	Curvature (Excess of extra response to second dressing over response to first dressing) N	P	K	St. error
				ROOTS (washed) : tons per acre						
1	Allscott ..	*7.79*	−0.51	+1.09	+0.62	±0.594	+0.11	−0.31	+0.86	±1.03
2	Bardney 1 (Meth.) ..	*9.36*	+0.66**	−0.07	+0.10	±0.167	−0.08	+0.05	+0.14	±0.289
3	Bardney 2 (Horn.) ..	*11.06*	+0.50	−0.66	−0.20	±0.343	−0.06	−1.44*	−0.50	±0.594
4	Brigg 1 (Caistor)	*10.34*	+3.51**	+0.48	+0.07	±0.394	−1.59*	−0.28	−0.63	±0.682
5	Brigg 2 (Scotton)	*9.41*	+2.93**	+0.59	−0.48	±0.373	−0.45	−0.87	−0.76	±0.646
6	Bury	*9.27*	+1.14**	+0.42	+0.04	±0.338	+0.60	−0.24	+0.66	±0.585
7	Cantley ..	*12.77*	+0.84	+0.31	+0.47	±0.425	0.00	−0.15	−0.47	±0.736
8	Colwick 1 (Cast.) ..	*12.44*	+2.06**	−0.59	+0.69	±0.594	−0.12	−1.45	−1.33	±1.03
9	Colwick 2 (Dent.) ..	*9.66*	+0.35	−0.25	−0.20	±0.319	+0.23	−0.37	+0.14	±0.552
10	Ely	*11.75*	+0.30	−0.32	+1.16*	±0.481	−0.78	+0.62	+0.56	±0.833
11	Felstead ..	*9.84*	+1.13	+0.40	+0.42	±0.575	+1.17	−0.24	+0.94	±0.996
12	Ipswich ..	*8.18*	+0.61	−0.63	+0.63	±0.485	−1.79	+0.75	−0.29	±0.841
13	Kidderminster	*5.31*	+0.70**	+0.34	+1.13**	±0.232	−0.08	−0.32	−0.07	±0.402
14	Kings Lynn ..	*8.01*	+0.84*	−0.05	−0.07	±0.289	−0.16	+0.33	+0.33	±0.501
15	Newark ..	*7.38*	+0.42	−0.56	−0.45	±0.418	−0.16	+1.02	+0.63	±0.723
16	Oaklands ..	*6.06*	+0.96**	+0.52	+0.79**	±0.242	+0.06	−0.16	−1.05*	±0.420
17	Peterborough 1 (Thor.) ..	*12.08*	+0.86	+0.23	−0.79	±0.566	+0.86	−0.85	−0.43	±0.980
18	Peterborough 2 (Tall.) ..	*12.98*	+1.85*	+0.06	+0.25	±0.824	+0.51	−0.42	−1.67	±1.43
19	Poppleton ..	*10.74*	+1.47*	+0.84	−0.41	±0.669	−0.93	+1.60	−1.37	±1.16
20	Selby	*11.97*	+1.25**	+0.30	−0.16	±0.359	−1.45*	0.00	+0.44	±0.621
21	Tunstall ..	*5.43*	+2.29**	+0.11	−0.05	±0.252	+0.93	−0.61	+0.03	±0.436
22	Wissington 1 (Crimp.) ..	*8.62*	+0.86*	−0.35	+0.26	±0.351	+0.02	+0.79	+0.14	±0.608
23	Wissington 2 (Wimb.) ..	*8.82*	+0.85	+0.61	−0.26	±0.712	−0.45	+1.17	−0.30	±1.23
	Mean	*9.53*	*+1.12*	*+0.12*	*+0.16*		*−0.16*	*−0.06*	*−0.17*	

https://doi.org/10.23637/ERADOC-1-67

	Station	*Mean*	Linear (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									
1	Allscott ..	*16.00*	−0.35	+0.17	+0.02	±0.257	+0.37	+0.07	−0.08	±0.446
2	Bardney 1 (Meth.) ..	*16.81*	−1.30**	−0.16	+0.65**	±0.115	−0.42*	+0.84**	−0.17	±0.200
3	Bardney 2 (Horn.) ..	*16.59*	−0.70**	+0.07	+0.16	±0.154	−0.30	−0.19	+0.24	±0.268
4	Brigg 1 (Caistor) ..	*17.38*	−0.61**	+0.33*	+0.41*	±0.139	−0.55*	−0.43	−0.35	±0.241
5	Brigg 2 (Scotton) ..	*16.59*	−0.56**	−0.06	−0.09	±0.184	−0.34	−0.18	+0.27	±0.318
6	Bury	*17.20*	−0.71**	+0.45*	+0.04	±0.164	−0.27	+0.51	+0.24	±0.284
7	Cantley ..	*17.38*	−0.68**	−0.48*	+0.16	±0.170	−0.40	+0.16	−0.52	±0.294
8	Colwick 1 (Cast.) ..	*17.45*	−1.09**	+0.01	−0.09	±0.278	+0.05	+0.09	−1.03	±0.482
9	Colwick 2 (Dent) ..	*17.02*	−0.39	−0.24	+0.29	±0.188	−0.03	+0.22	−0.51	±0.326
10	Ely	*14.63*	−0.40	−0.07	+1.34**	±0.409	−1.18	+0.45	−0.64	±0.708
11	Felstead ..	*17.00*	−0.48*	+0.17	+0.28	±0.205	+0.16	−0.47	−0.08	±0.355
12	Ipswich ..	*16.99*	−0.15	−0.16	+0.18	±0.350	−0.29	+0.46	+0.24	±0.606
13	Kidderminster	*15.87*	−0.34*	−0.04	+0.16	±0.117	+0.42	+0.42	+0.12	±0.202
14	Kings Lynn ..	*19.45*	−1.47**	−0.44	+0.54	±0.477	−0.77	+0.04	+0.10	±0.826
15	Newark ..	*16.60*	−0.43**	−0.04	−0.01	±0.139	−0.39	+0.04	+0.27	±0.242
16	Oaklands ..	*16.00*	−0.65**	+0.29	+0.45**	±0.147	+0.33	−0.15	−0.09	±0.255
17	Peterborough 1 (Thor.) ..	*16.43*	−0.11	−0.15	+0.02	±0.123	−0.11	+0.09	−0.04	±0.212
18	Peterborough 2 (Tall.) ..	*17.10*	−0.37*	+0.18	+0.19	±0.152	−0.05	+0.22	−0.25	±0.264
19	Poppleton ..	*17.64*	−0.54*	+0.05	−0.04	±0.199	+0.70	+0.11	−0.26	±0.345
20	Selby	*18.54*	−0.44*	+0.27	−0.05	±0.180	−0.20	−0.11	+0.01	±0.313
21	Tunstall ..	*16.34*	−1.06**	+0.05	+0.32	±0.163	−0.46	−0.49	+0.28	±0.282
22	Wissington 1 (Crimp.) ..	*18.24*	−1.10**	−0.05	+0.24	±0.171	−0.42	+0.39	+0.34	±0.297
23	Wissington 2 (Wimb.) ..	*16.32*	−0.56**	−0.06	+0.28	±0.133	+0.24	+0.04	+0.10	±0.230
	Mean	*16.94*	*−0.63*	*0.00*	*+0.24*		*−0.17*	*+0.09*	*−0.08*	

https://doi.org/10.23637/ERADOC-1-67

	Station	*Mean Yield*	Linear Response (response to the double dressing) N	P	K	Curvature (Excess of extra response to second dressing over response to first dressing) N	P	K
	TOTAL SUGAR: cwt. per acre							
1	Allscott	*25.0*	−2.2	+3.7	+2.0	+1.0	−1.1	+2.6
2	Bardney 1 (Meth.) ..	*31.4*	−0.2	−0.4	+1.5	−1.2	+6.8	+0.1
3	Bardney 2 (Horn.) ..	*36.7*	+0.2	−2.1	−0.2	−1.0	−5.1	−1.0
4	Brigg (Caistor) ..	*35.9*	+11.0	+2.3	+1.0	−7.0	−1.9	−2.8
5	Brigg (Scotton) ..	*31.2*	+8.6	+1.7	−1.7	−2.4	−3.3	−1.9
6	Bury	*31.8*	+2.6	+2.3	+0.2	+1.6	+0.1	+2.8
7	Cantley	*44.4*	+1.2	−0.1	+1.9	−1.0	−0.1	−3.1
8	Colwick 1 (Cast.) ..	*43.4*	+4.5	−2.1	+2.2	−0.7	−5.1	−7.2
9	Colwick 2 (Dent.) ..	*32.8*	+0.5	−1.3	−0.1	+0.7	−0.7	−0.5
10	Ely	*34.4*	0.0	−1.0	+6.5	−5.0	+2.8	+0.3
11	Felstead	*33.4*	+2.8	+1.6	+1.9	+4.0	−1.6	+3.1
12	Ipswich	*27.8*	+1.7	−2.4	+2.5	−6.7	+3.2	−0.5
13	Kidderminster ..	*16.9*	+2.0	+1.1	+3.7	+0.2	−0.7	−0.1
14	Kings Lynn	*31.1*	+0.8	−1.0	+0.7	−2.2	+1.2	+1.5
15	Newark	*24.5*	+0.7	−2.0	−1.5	−0.9	+3.4	+2.5
16	Oaklands	*19.4*	+2.3	+2.0	+3.0	+0.5	−0.6	−3.6
17	Peterborough 1 (Thor.)	*39.6*	+2.6	+0.3	−2.5	+2.6	−2.5	−1.7
18	Peterborough 2 (Tall.)	*44.4*	+5.4	+0.7	+1.3	+1.8	−0.9	−6.3
19	Poppleton	*37.8*	+4.2	+3.2	−1.5	−2.0	+6.0	−5.3
20	Selby	*44.4*	+3.6	+1.7	−0.7	−6.0	−0.1	+1.7
21	Tunstall	*17.7*	+6.3	+0.5	+0.3	+2.3	−2.5	+0.5
22	Wissington 1 (Crimp.)	*31.4*	+1.4	−1.3	+1.3	−0.8	+3.5	+0.7
23	Wissington 2 (Wimb.)	*28.8*	+1.9	+1.8	−0.5	−1.1	+3.8	−0.9
	Mean	32.4	*+2.7*	*+0.4*	*+0.9*	*−1.0*	*+0.2*	*−0.8*

https://doi.org/10.23637/ERADOC-1-67

	Station	*Mean*	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
	PLANT NUMBER : thousands per acre							
1	Allscott	*30.0*	−2.8	+2.4	+2.0	−5.6	+1.6	+1.8
2	Bardney 1 (Meth.) ..	*27.7*	−0.4	−0.4	−0.3	+1.0	−0.8	+0.1
3	Bardney 2 (Horn.) ..	*25.0*	−0.6	−1.3	+0.1	−2.8	−1.9	−0.1
4	Brigg 1 (Caistor) ..	*25.4*	+2.8	0.0	+0.1	−0.6	+0.6	−1.9
5	Brigg 2 (Scotton) ..	*33.7*	+2.4	−1.1	0.0	−0.2	−1.7	−1.4
6	Bury	*26.1*	+2.5	−0.8	+0.7	−0.3	+1.2	+1.7
7	Cantley	*31.6*	+0.9	−3.3	+0.2	+6.5	−0.7	+1.8
8	Colwick 1 (Cast.) ..	*33.2*	−0.7	−0.6	+0.6	−1.3	+0.4	+0.2
9	Colwick 2 (Dent.) ..	*25.8*	−0.2	−0.6	0.0	−0.6	−0.2	−1.2
10	Ely	*31.2*	−5.2	−0.6	+1.0	0.0	−5.6	−0.8
11	Felstead	*20.6*	+1.3	+1.5	+0.2	+0.5	+0.9	+0.6
13	Kidderminster ..	*28.3*	−1.4	+0.8	+2.0	−2.0	+3.0	+0.4
14	Kings Lynn	*32.8*	0.0	−1.1	+0.5	+0.4	+0.1	−0.9
15	Newark	*29.9*	+0.6	−0.6	+0.7	+2.6	−1.8	−1.9
16	Oaklands	*23.6*	+0.6	−0.6	+0.6	+1.8	0.0	−1.6
17	Peterborough 1 (Thor.)	*23.8*	+1.6	−0.8	+0.1	−2.8	0.0	−2.5
18	Peterborough 2 (Tall.)	*26.6*	+0.3	+0.2	−0.1	−1.1	+0.2	+0.7
19	Poppleton	*26.9*	+3.0	+0.6	−3.7	−2.0	+1.0	−1.1
20	Selby	*33.6*	+0.4	+1.2	−0.2	−3.6	−1.8	−1.8
21	Tunstall	*59.1*	−0.6	+1.3	−1.7	−1.4	−1.1	−1.5
22	Wissington 1 (Crimp.)	*28.2*	−0.6	+0.7	+0.7	+0.4	+0.1	+0.7
23	Wissington 2 (Wimb.)	*31.1*	+2.3	+2.4	−1.4	−1.9	−1.6	+1.4
	Mean	*29.7*	*+0.3*	*0.0*	*+0.1*	*−0.6*	*−0.4*	*−0.3*

	Station	*Mean Yield*	Linear response (response to the double dressing) N	P	K	St. error	Curvature (Excess of extra response to second dressing over response to first dressing) N	P	K	St. error
		TOPS: tons per acre								
1	Allscott ..	*7.70*	+0.78	+1.20	+0.59	±0.598	−0.30	+0.24	−0.77	±1.04
2	Bardney 1 (Meth.) ..	*7.38*	+3.12**	+0.34	−0.49	±0.238	+0.64	−1.10	+0.15	±0.413
3	Bardney 2 (Horn.) ..	*9.52*	+3.05**	−0.35	−0.05	±0.500	+0.33	+0.55	−0.51	±0.865
4	Brigg 1 (Caistor) ..	*6.95*	+4.92**	−0.48	−0.40	±0.322	+0.70	+0.60	+0.14	±0.558
5	Brigg 2 (Scotton)	*7.54*	+4.72**	+0.11	−0.16	±0.254	+0.14	−0.67	−1.00*	±0.440
6	Bury ..	*7.26*	+2.50**	−0.15	+0.41	±0.305	−0.40	−0.23	−0.43	±0.529
7	Cantley ..	*9.13*	+2.71**	+0.12	−0.53	±0.424	+1.37	−0.18	−0.67	±0.733
8	Colwick 1 (Cast.) ..	*8.08*	+4.03**	−0.85	+1.13*	±0.394	−0.07	−0.37	−0.23	±0.682
9	Colwick 2 (Dent.) ..	*8.33*	+1.75**	+0.68	+0.36	±0.381	−0.01	+0.18	−0.72	±0.659
10	Ely ..	*20.41*	−3.60	0.00	+0.85	±2.32	−3.78	−5.26	+5.31	±4.02
11	Felstead ..	*3.53*	+0.53	+0.72	−0.99	±0.811	+2.07	−0.20	+0.29	±1.40
13	Kidderminster	*6.28*	+1.86**	+0.22	+0.36	±0.289	−0.24	−0.96	−0.20	±0.501
14	Kings' Lynn..	*3.95*	+1.53**	−0.23	+0.24	±0.448	+0.63	+0.09	−1.52	±0.776
15	Newark ..	*7.93*	+4.34**	−0.49	−0.48	±0.646	+1.14	+1.77	+0.96	±1.12
16	Oaklands ..	*6.54*	+3.31**	+0.26	−0.24	±0.230	−0.59	+0.52	−0.34	±0.398
17	Peterborough 1 (Thor.) ..	*14.60*	+2.66	+1.50	−2.21	±1.29	−0.90	+0.44	−2.67	±2.23
18	Peterborough 2 (Tall.) ..	*5.83*	+1.95**	−0.40	−0.15	±0.351	+0.89	+0.42	+0.23	±0.608
19	Poppleton ..	*7.38*	+3.32*	+0.25	+1.14	±1.16	−1.62	+0.81	−1.02	±2.02
20	Selby ..	*9.40*	+4.02**	+1.01	+0.14	±0.570	−0.30	+1.03	+0.66	±0.988
21	Tunstall ..	*4.92*	+3.71**	−0.01	+0.14	±0.456	+0.83	+0.29	−0.22	±0.789
	Mean ..	*8.13*	*+2.56*	*+0.17*	*−0.02*		*+0.03*	*−0.10*	*−0.13*	

https://doi.org/10.23637/ERADOC-1-67

	Station	*Mean*	Linear response (response to the double dressing) N	P	K	St. error	Curvature (Excess of extra response to second dressing over response to first dressing) N	P	K	St. error
	PERCENTAGE PURITY									
1	Allscott ..	*87.1*	−1.6	+0.2	+0.2	±0.803	−0.8	−0.2	+0.6	±1.39
2	Bardney 1 (Meth.) ..	*87.1*	−1.0	−0.5	−0.2	±0.550	−0.6	+0.5	0.0	±0.953
3	Bardney 2 (Horn.) ..	*86.6*	+0.2	−0.2	+0.6	±0.453	+0.4	−1.4	+1.0	±0.785
4	Brigg 1 (Caistor) ..	*89.5*	−0.8**	+0.5*	+0.5*	±0.212	−0.6	−0.5	+0.1	±0.367
5	Brigg 2 (Scotton)	*87.0*	−1.2*	−0.1	+0.6	±0.414	−1.2	+0.5	+0.6	±0.717
6	Bury ..	*90.4*	−1.4**	+0.2	−0.3	±0.346	−0.2	−0.2	+0.1	±0.599
7	Cantley ..	*93.3*	−0.9	0.0	+2.5	±1.22	−1.5	+2.2	+0.3	±2.11
8	Colwick 1 (Cast.) ..	*87.6*	0.0	+0.6	+0.5	±0.552	−0.6	−0.6	+0.3	±0.956
9	Colwick 2 (Dent.) ..	*86.2*	+0.1	+0.3	+0.3	±0.252	−0.9*	−0.5	+0.1	±0.436
10	Ely ..	*85.7*	−0.1	−0.4	+0.4	±0.621	−0.1	+0.2	0.0	±1.08
11	Felstead ..	*86.6*	+0.1	−0.4	0.0	±0.241	−0.1	−1.0*	−0.4	±0.418
12	Ipswich ..	*92.1*	+1.1	−1.1	−1.0	±1.03	+0.7	+4.1*	+1.6	±1.78
13	Kidderminster	*86.3*	−1.0*	+0.3	0.0	±0.407	−0.8	+0.1	−0.8	±0.706
14	King's Lynn..	*85.2*	−2.0	+0.8	−0.4	±1.00	−1.8	−2.4	−1.2	±1.73
17	Peterborough 1 (Thor.) ..	*82.6*	−0.4	−0.6	−0.4	±0.325	−1.2	−0.6	+0.2	±0.562
18	Peterborough 2 (Tall.) ..	*87.6*	−1.8	+1.2	+0.2	±0.946	−0.6	+0.6	−1.0	±1.64
19	Poppleton ..	*88.2*	−0.1	−0.1	+0.1	±0.344	+0.5	+0.1	+0.1	±0.596
20	Selby ..	*88.8*	+0.1	+0.7	+0.4	±0.343	−0.7	−0.1	+0.8	±0.593
22	Wissington 1 (Crimp.) ..	*89.6*	−1.6*	−0.8	+0.4	±0.587	−0.6	+0.8	0.0	±1.02
23	Wissington 2 (Wimb.) ..	*90.4*	-1.1**	+0.5	0.0	±0.348	+0.5	+1.3	+0.4	±0.602
	Mean ..	*87.9*	*−0.7*	*+0.1*	*+0.2*		*−0.5*	*+0.1*	*+0.1*	

https://doi.org/10.23637/ERADOC-1-67

Interactions.

	Station	Interaction of linear responses (one half of the extra response to one fertiliser through the addition of a second) N×P	N×K	P×K	St. error	Interaction of linear responses (one half of the extra response to one fertiliser through the addition of a second) N×P	N×K	P×K	St. error
		ROOTS (washed) : tons per acre				SUGAR PERCENTAGE			
1	Allscott	+0.38	−0.28	−0.62	±0.727	−0.34	−0.05	+0.45	±0.315
2	Bardney 1 (Meth.) ..	−0.41	+0.46*	−0.04	±0.204	−0.08	+0.10	−0.12	±0.141
3	Bardney 2 (Horn.) ..	+1.04*	−1.12*	−0.28	±0.420	−0.42*	−0.02	0.00	±0.189
4	Brigg 1 (Caistor) ..	+0.24	+0.38	−0.25	±0.483	+0.15	−0.08	+0.24	±0.170
5	Brigg 2 (Scotton) ..	−0.21	−0.14	−0.52	±0.457	−0.40	+0.22	−0.04	±0.225
6	Bury	−0.04	0.00	+0.35	±0.414	+0.12	+0.26	0.00	±0.201
7	Cantley	−0.43	+0.78	+0.74	±0.521	−0.10	−0.10	+0.08	±0.208
8	Colwick 1 (Cast.) ..	−0.04	+0.89	−1.13	±0.727	−0.17	+0.18	+0.20	±0.341
9	Colwick 2 (Dent.) ..	+0.16	+0.30	+0.10	±0.390	−0.12	+0.13	−0.26	±0.231
10	Ely	+0.06	−0.06	−0.58	±0.589	−0.63	+0.40	+0.94	±0.500
11	Felstead	+1.26	−0.24	−1.84*	±0.704	+0.50	−0.10	−0.50	±0.251
12	Ipswich	+0.30	+0.09	+0.04	±0.595	+0.04	−0.12	+0.02	±0.428
13	Kidderminster ..	−0.24	+0.30	−0.44	±0.284	+0.04	−0.17	+0.24	±0.143
14	Kings Lynn	+0.22	+0.34	+0.22	±0.354	−1.12	+0.86	+0.12	±0.584
15	Newark	−0.32	+0.06	−0.02	±0.512	−0.28	+0.17	−0.44*	±0.171
16	Oaklands	+0.54	+0.48	−0.02	±0.297	−0.18	−0.10	−0.10	±0.180
17	Peterborough 1 (Thor.)	−0.02	−0.44	+1.66*	±0.693	+0.07	−0.13	−0.12	±0.150
18	Peterborough 2 (Tall.)	−0.39	+0.20	−0.73	±1.01	−0.14	−0.35	+0.17	±0.187
19	Poppleton	−1.08	+1.30	+0.06	±0.820	+0.66*	+0.16	+0.14	±0.244
20	Selby	+0.26	+1.00*	+0.78	±0.439	−0.06	+0.22	−0.02	±0.221
21	Tunstall	−0.26	+0.10	+0.50	±0.308	+0.13	+0.23	+0.08	±0.200
22	Wissington 1 (Crimp.)	−0.56	+0.54	−0.44	±0.430	−0.44*	+0.20	+0.22	±0.210
23	Wissington 2 (Wimb.)	+0.58	+0.38	−0.61	±0.872	−0.16	−0.14	−0.08	±0.163
	Mean	*+0.04*	*+0.23*	*−0.13*		*−0.13*	*+0.08*	*+0.05*	

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	Station	Interaction of linear responses (one half of the extra response to one fertiliser through the addition of a second) N×P	N×K	P×K	Interaction of linear responses (one half of the extra response to one fertiliser through the addition of a second) N×P	N×K	P×K
		TOTAL SUGAR : cwt. per acre			PLANT NUMBER: thousands per acre		
1	Allscott	+0.6	−1.0	−1.1	+0.4	+2.0	+4.9
2	Bardney 1 (Meth.) ..	−1.6	+1.6	−0.4	+0.8	0.0	−0.4
3	Bardney 2 (Horn.) ..	+2.4	−3.7	−1.0	+2.2	−2.2	−0.8
4	Brigg 1 (Caistor)	+1.3	+1.2	−0.2	+0.1	−0.2	−0.7
5	Brigg 2 (Scotton)	−1.4	0.0	−1.8	+1.8	+0.6	−0.8
6	Bury	+0.2	+0.5	+1.2	−0.8	+1.0	+0.3
7	Cantley	−1.9	+2.4	+2.8	+0.2	−0.5	−0.2
8	Colwick 1 (Cast.)	−0.4	+3.6	−3.6	−0.5	+0.2	+0.5
9	Colwick 2 (Dent.) ..	+0.3	+1.3	−0.2	+1.1	+0.2	−0.3
10	Ely	−1.1	+0.6	+0.4	−1.4	−3.0	−2.0
11	Felstead	+5.3	−1.0	−7.2	+1.4	−1.0	−2.6
12	Ipswich	+1.0	+0.1	+0.1	—	—	—
13	Kidderminster	−0.8	+0.7	−1.0	−0.4	+0.2	+0.7
14	Kings Lynn	−1.0	+2.8	+1.0	+0.4	+0.6	−1.2
15	Newark	−1.4	+0.4	−0.7	+0.8	+0.4	−0.2
16	Oaklands	+1.4	+1.4	−0.2	+0.4	+1.4	+0.2
17	Peterborough 1 (Thor.) ..	0.0	−1.7	+5.2	+0.6	−1.0	+0.2
18	Peterborough 2 (Tall.) ..	−1.7	−0.2	−2.0	−0.1	+0.4	+0.6
19	Poppleton	−2.4	+5.0	+0.5	−0.5	+2.1	+0.8
20	Selby	+0.8	+4.2	+2.9	+1.2	−0.2	+1.0
21	Tunstall	−0.8	+0.7	+0.2	+0.6	−0.6	+0.8
22	Wissington 1 (Crimp.) ..	−2.7	+2.2	−1.2	−0.2	−1.0	+0.4
23	Wissington 2 (Wimb.) ..	+1.6	+1.0	−2.2	+2.0	+0.5	−4.4
	Mean	*−0.1*	*+1.0*	*−0.4*	*+0.5*	*0.0*	*−0.2*

	Station	Interaction of linear responses (one half of the extra response to one fertiliser through the addition of a second) N×P	N×K	P×K	St. error	Interaction of linear responses (one half of the extra response to one fertiliser through the addition of a second) N×P	N×K	P×K	St. error
		TOPS: tons per acre				PERCENTAGE PURITY			
1	Allscott	+0.56	+0.25	+0.08	±0.733	+0.4	+0.5	+0.4	±0.984
2	Bardney 1 (Meth.)	−0.03	−0.34	−0.40	±0.292	−1.0	−0.1	0.0	±0.674
3	Bardney 2 (Horn.)	+0.65	−0.44	+1.24	±0.612	−0.3	+0.4	−0.6	±0.555
4	Brigg 1 (Caistor)	−0.50	+0.14	−0.95*	±0.394	−0.4	−0.2	0.0	±0.259
5	Brigg 2 (Scotton)	−0.16	−0.69*	−0.06	±0.311	0.0	+0.8	+0.1	±0.507
6	Bury	−0.32	+0.24	−0.34	±0.374	0.0	+0.4	−0.6	±0.424
7	Cantley	+0.82	+0.30	+0.08	±0.518	−0.2	+0.2	−0.5	±1.49
8	Colwick 1 (Cast.)	−0.92	+0.39	−0.10	±0.482	+0.8	+0.2	−0.3	±0.676
9	Colwick 2 (Dent.)	+0.78	+0.50	−0.02	±0.466	+0.7*	−0.6	−0.5	±0.308
10	Ely	−0.72	+2.11	+1.54	±2.85	−1.0	+0.6	+2.2*	±0.760
11	Felstead	−0.75	0.00	−0.83	±0.993	+0.1	+0.3	−0.2	±0.296
12	Ipswich	—	—	—	—	−1.0	+1.0	+0.4	±1.26
13	Kidderminster	+0.48	+0.64	−0.66	±0.354	+0.1	−0.5	−0.4	±0.499
14	King's Lynn	+0.20	+0.04	+0.69	±0.548	+0.8	−1.1	+2.2	±1.23
15	Newark	+0.10	−0.21	+0.22	±0.791	—	—	—	—
16	Oaklands	+0.40	+0.32	−0.18	±0.282	—	—	—	—
17	Peterborough 1 (Thor.)	−0.84	+1.12	+2.17	±1.58	−0.4	−0.8	−0.5	±0.398
18	Peterborough 2 (Tall.)	+0.14	−0.16	+0.10	±0.430	−1.0	−1.7	+0.8	±1.16
19	Poppleton	−1.62	+1.78	−0.34	±1.43	−0.4	+0.2	0.0	±0.421
20	Selby	+1.22	+0.30	+0.86	±0.699	0.0	+0.5	+0.3	±0.420
21	Tunstall	0.00	+0.19	−0.22	±0.558	—	—	—	—
22	Wissington 1 (Crimp.)	—	—	—	—	+0.2	+0.1	+1.0	±0.719
23	Wissington 2 (Wimb.)	—	—	—	—	+0.6	−0.5	+0.3	±0.426
	Mean	*−0.03*	*+0.32*	*+0.14*		*−0.1*	*0.0*	*+0.2*	

Conclusions

Effects of sulphate of ammonia

Sulphate of ammonia produced significant increases in the yield of roots at thirteen of the twenty-three centres. Of the remaining ten centres, all except Allscott showed positive responses and the average increase at these centres was significant.

Sixteen of the twenty centres where tops were weighed showed significant increases. The remaining four were centres where the response in roots was not significant. At Ely, where the average yield of tops was 20 tons per acre, sulphate of ammonia depressed the yield of tops, though not significantly.

Sugar percentage was decreased at all centres, the decreases being significant at eighteen centres. The remaining five centres showed no significant response in roots. There was, however, no correlation between the actual sizes of the decrease in sugar percentage and of the increase in roots.

Percentage purity was significantly decreased at six of the twenty centres where it was measured. Of the remaining centres eight showed a negligible effect, five showed decreases of 1 per cent. or over and one (Ipswich) an increase of 1·1 per cent, which was within its standard error.

All the above effects were significantly different for the different centres, and except for percentage purity, remained significantly different when only those centres with a clear response were included.

In roots the additional response to the second dressing was significantly less than the response to the first dressing at two of the centres which showed a clear response in roots. There was no indication of any falling-off in response at the higher level of application at the other centres with a clear response in roots, or in the tops. The decrease in sugar percentage was significantly greater at the higher level of application than at the lower, and there are indications of the same effect in percentage purity.

Effects of superphosphate

There were no significant responses in roots or tops. Two centres showed significant increases in sugar percentage and one a significant decrease, but there was no apparent effect at any other centre. One centre gave a significant increase in percentage purity.

There was no general indication of any curvature of response, though a few individual curvatures were significant.

Effects of muriate of potash

The only significant average response was that in sugar percentage, which was significantly different at the different centres. Four centres showed a significant response. Two of these also showed a significant response in roots, but there was in general no correlation between the effect on roots and that on sugar percentage.

At the four centres with a significant response the additional response to the double dressing was less than that to the single dressing, but the differences were small and the average was not significant.

Interactions

The only significant average interaction between sulphate of ammonia and superhposphate was a negative one in sugar percentage (i.e., sulphate of ammonia decreased sugar percentage more with the double dressing of superphosphate than with the zero dressing). This was significantly different at the different centres, being significantly negative at two centres and significantly positive at one centre.

The average interaction in roots between sulphate of ammonia and muriate of potash was positive and just significant at the 5 per cent. level. One centre gave a significant negative interaction, but there the responses to sulphate of ammonia and muriate of potash were not significant.

There were no significant average interactions between potash and phosphate.

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EXPERIMENTS AT OUTSIDE CENTRES

Barley. South Eastern Agricultural College, Wye, Kent, 1935

6×6 Latin square. Plots : 0.008287 acre.

TREATMENTS : Sulphate of ammonia and nitro-chalk at the rate of 0 and 0.2 cwt. N alone and with superphosphate at the rate of 0 and 0.4 cwt. P_2O_5 per acre.

BASAL MANURING : Nil.

SOIL : Light loam on chalk. Variety : Plumage Archer. Manures applied : March 8. Seed sown : March 8. Harvested : August 8. Previous crop : Barley.

SPECIAL NOTE : Harvested for grain and straw ratio by sampling method. Seven sampling units per plot each consisting of 4 half metre rows side by side. Rows spaced 7 ins. apart.

STANDARD ERRORS PER PLOT : Grain : 2.36 cwt. per acre or 11.8% ; straw : 2.45 cwt. per acre or 11.4% ; plant number : 8.34 thous. per acre or 31.6%.

Grain : cwt. per acre (±0.964)

Superphosphate per acre	Nitrogen (0.2 cwt. N. per acre) None	Sulph. amm.	Nitro-chalk	*Mean (±0.556)*	*Increase (±0.786)*
None	17.3	20.4	22.6	*20.1*	
0.4 cwt. P_2O_5 ..	16.8	20.0	23.3	*20.0*	*−0.1*
Mean (±0.682) ..	*17.0*	*20.2*	*23.0*	*20.1*	
Increase (±0.964) ..		*+3.2*	*+6.0*		

Straw : cwt. per acre (±1.00)

Superphosphate per acre	Nitrogen (0.2 cwt. N per acre) None	Sulph. amm.	Nitro-chalk	*Mean (±0.577)*	*Increase (±0.816)*
None	17.6	21.5	24.9	*21.3*	
0.4 cwt. P_2O_5	17.3	23.2	23.8	*21.4*	*+0.1*
Mean (±0.707) ..	*17.4*	*22.4*	*24.4*	*21.4*	
Increase (±1.00) ..		*+5.0*	*+7.0*		

Plant number (May 16) : thousands per acre (±3.40)

Superphosphate per acre	Nitrogen (0.2 cwt. N per acre) None	Sulph. amm.	Nitro-chalk	*Mean (±1.96)*	*Increase (±2.77)*
None	20.5	22.6	28.6	*23.9*	
0.4 cwt. P_2O_5 ..	21.9	33.5	31.3	*28.9*	*+5.0*
Mean (±2.40) ..	*21.2*	*28.0*	*30.0*	*26.4*	
Increase (±3.40) ..		*+6.8*	*+8.8*		

Conclusions

Sulphate of ammonia and nitro-chalk significantly increased the yields of grain and straw and the plant number, the increase in grain being significantly greater for nitro-chalk than for sulphate of ammonia. Superphosphate had no apparent effect on yields.

https://doi.org/10.23637/ERADOC-1-67

Potatoes—W. E. Morton, Esq., Gores Farm, Thorney, Peterborough, 1935

3 randomised blocks of 9 plots each, with two degrees of freedom, representing second order interactions, confounded with block differences. Error estimated from high order interactions.

PLOTS : 1/60 acre.

TREATMENTS : All combinations of :

Sulph. Amm. {None, 0.3 cwt. N, 0.6 cwt. N} × Super. {None, 0.75 cwt. P_2O_5, 1.50 cwt. P_2O_5} × Sulph. pot. {None, 0.75 cwt. K_2O, 1.50 cwt. K_2O}

BASAL MANURING : 12 loads dung.

SOIL : Light black land. Variety : Majestic. Manures applied : Apr. 2nd. Potatoes planted : Apr. 4th. Lifted : Oct. 7th. Previous crop : Oats.

SPECIAL NOTE : 1 cwt. of potatoes from each plot passed over a $1\frac{5}{8}$ inch riddle to determine the percentage ware.

STANDARD ERRORS PER PLOT : Total produce : 1.40 tons per acre or 16.6%. Percentage ware : 4.94.

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 (±0.808. *Means: ±0.466. Increases: ±0.659*)								
0.0 cwt. N	..	7.62	6.99	9.34	7.68	7.49	8.78	*7.98*	
0.3 cwt. N	..	8.84	9.45	8.71	8.17	9.45	9.38	*9.00*	*+1.02*
0.6 cwt. N	..	7.70	8.04	8.95	7.74	8.55	8.40	*8.23*	*−0.77*
Mean ..	..	*8.05*	*8.16*	*9.00*	*7.86*	*8.50*	*8.85*	*8.40*	
Increase	..		*+0.11*	*+0.84*		*+0.64*	*+0.35*		
	Percentage ware : (±2.85. *Means: ±1.64. Increases: ±2.32*)								
0.0 cwt. N	..	82.7	85.6	90.4	87.8	87.2	83.6	*86.2*	
0.3 cwt. N	..	84.3	87.8	89.4	87.2	86.2	88.1	*87.2*	*+1.0*
0.6 cwt. N	..	84.3	83.3	84.6	86.5	81.7	84.0	*84.1*	*−3.1*
Mean ..	..	*83.8*	*85.6*	*88.1*	*87.2*	*85.0*	*85.2*	*85.8*	
Increase	..		*+1.8*	*+2.5*		*−2.2*	*+0.2*		

Interaction of sulphate of potash with superphosphate

Sulphate of Potash	Total produce : tons per acre (±0.808) Superphosphate (cwt. P_2O_5) 0.00	0.75	1.50	Percentage ware (±2.85) Superphosphate (cwt. P_2O_5) 0.00	0.75	1.50
0.00 cwt. K_2O ..	8.30	7.20	8.08	85.2	89.4	86.8
0.75 cwt. K_2O ..	8.74	7.37	9.38	84.9	80.1	90.1
1.50 cwt. K_2O ..	7.12	9.91	9.54	81.1	87.2	87.5

Conclusions

No significant effects.

Potatoes—A. S. Rickwood, Esq., Mepal, Isle of Ely, 1935

3 randomised blocks of 9 plots each, with two degrees of freedom, representing second order interactions, confounded with block differences. Error estimated from high order interactions.

PLOTS : 1/60 acre.

TREATMENTS : All combinations of :

Sulph. amm.		Super.		Sulph. pot.
None 0.3 cwt. N 0.6 cwt. N	×	None 0.75 cwt. P_2O_5 1.50 cwt. P_2O_5	×	None 0.75 cwt. K_2O 1.50 cwt. K_2O

BASAL MANURING : Nil.

SOIL : Deep light peaty fen. Variety : Scotch King Edward. Manures applied : Apr. 3rd. Potatoes planted : Apr. 17th. Lifted : Sept. 23rd. Previous crop : Wheat.

SPECIAL NOTE : Potatoes passed over 1⅝ inch riddle to determine percentage ware.

STANDARD ERRORS PER PLOT : Total produce : 1.24 tons per acre or 13.1%. Percentage ware : 8.39.

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 (±0.718. *Means: ±0.414. Increases: ±0.585*)							
0.0 cwt. N ..	8.01	8.88	9.55	6.96	9.14	10.34	*8.81*	
0.3 cwt. N ..	8.99	10.37	9.27	7.57	9.09	11.97	*9.54*	*+0.73*
0.6 cwt. N ..	9.73	9.47	11.14	6.96	11.29	12.10	*10.12*	*+0.58*
Mean	*8.91*	*9.57*	*9.99*	*7.16*	*9.84*	*11.47*	*9.49*	
Increase ..		*+0.66*	*+0.42*		*+2.68*	*+1.63*		
	Percentage ware : (±4.85. *Means: ±2.80. Increases:* ±3.96)							
0.0 cwt. N ..	61.7	66.2	66.2	55.0	66.8	72.3	*64.7*	
0.3 cwt. N ..	58.9	66.3	60.4	53.1	57.8	74.8	*61.9*	*−2.8*
0.6 cwt. N ..	57.5	56.2	61.6	40.5	66.9	68.0	*58.5*	*−3.4*
Mean	*59.4*	*62.9*	*62.7*	*49.5*	*63.8*	*71.7*	*61.7*	
Increase ..		*+3.5*	*−0.2*		*+14.3*	*+7.9*		

Interaction of sulphate of potash with superphosphate

Sulphate of potash	Total produce : tons per acre (±0.718) Superphosphate (cwt. P_2O_5) 0.00	0.75	1.50	Percentage ware (±4.85) Superphosphate (cwt. P_2O_5) 0.00	0.75	1.50
0.00 cwt. K_2O ..	5.80	7.98	7.70	45.7	55.1	47.8
0.75 cwt. K_2O ..	9.30	9.96	10.26	61.2	64.5	65.7
1.50 cwt. K_2O ..	11.62	10.78	12.00	71.2	69.1	74.8

Conclusions

Sulphate of ammonia and sulphate of potash gave significant increases in yield, the increase to the double dressing of the latter being 4.3 tons per acre, or 45 per cent. of the mean yield of the experiment. The slight falling-off in response at the higher level of dressing was not significant in either case. Sulphate of potash also produced a large increase in percentage ware. There were no significant responses to superphosphate.

Potatoes—R. Starling, Esq., Little Downham, Ely, 1935

3 randomised blocks of 9 plots each, with two degrees of freedom, representing second order interactions, confounded with block differences. Error estimated from high order interactions.

PLOTS: 1/50 acre.

TREATMENTS: All combinations of:

Sulph. amm. {None, 0.5 cwt. N, 1.0 cwt. N} × Super. {None, 0.8 cwt. P_2O_5, 1.6 cwt. P_2O_5} × Sulph. pot. {None, 0.5 cwt. K_2O, 1.0 cwt. K_2O}

BASAL MANURING: Nil.

SOIL: Black soil. Variety: Ninety-fold. Manures applied: Mar. 7th. Potatoes planted: Mar. 12th. Lifted: July 30th. Previous crop: Sugar beet.

STANDARD ERRORS PER PLOT: Total produce: 0.582 tons per acre or 11.6%. Plant number: 0.841 thousands per acre or 7.29%.

Note.—An exceptionally severe frost on May 17th completely killed the tops when they were about 10 inches high.

Main effects. Interactions of sulphate of ammonia with superphosphate and sulphate of potash

Sulphate of ammonia	Superphosphate (cwt. P_2O_5) 0.0	0.8	1.6	Sulphate of potash (cwt. K_2O) 0.0	0.5	1.0	*Mean*	*Increase*
Total produce: tons per acre (±0.336. *Means*: ±0.194. *Increases*: ±0.274)								
0.0 cwt. N	3.09	3.83	3.57	3.30	3.70	3.49	*3.50*	
0.5 cwt. N	3.85	5.30	5.94	4.50	5.04	5.54	*5.03*	*+1.53*
1.0 cwt. N	4.79	6.89	7.92	6.40	7.14	6.06	*6.53*	*+1.50*
Mean	*3.91*	*5.34*	*5.81*	*4.73*	*5.29*	*5.03*	*5.02*	
Increase ..	*+1.43*	*+0.47*		*+0.56*	*−0.26*			
Plant number: thousands per acre (±0.486. *Means*: ±0.281. *Increases*: ±0.397)								
0.0 cwt. N	10.8	11.2	9.9	10.5	11.2	10.1	*10.6*	
0.5 cwt. N	11.0	12.2	12.0	11.2	12.0	11.9	*11.7*	*+1.1*
1.0 cwt. N	11.0	12.2	13.7	12.1	12.7	12.1	*12.3*	*+0.6*
Mean	*10.9*	*11.8*	*11.8*	*11.3*	*12.0*	*11.4*	*11.6*	
Increase ..	*+0.9*	*0.0*		*+0.7*	*−0.6*			

Interaction of sulphate of potash with superphosphate

Sulphate of potash	Total produce: tons per acre (±0.336) Superphosphate (cwt. P_2O_5) 0.0	0.8	1.6	Plant number: thousands per acre (±0.486) Superphosphate (cwt. P_2O_5) 0.0	0.8	1.6
0.0 cwt. K_2O.. ..	3.77	5.20	5.22	10.1	12.5	11.3
0.5 cwt. K_2O.. ..	4.21	5.70	5.97	11.6	11.8	12.5
1.0 cwt. K_2O.. ..	3.74	5.13	6.23	11.1	11.3	11.8

Conclusions

Sulphate of ammonia gave a significant increase in yield, with no sign of deviation from proportionality of response to the amount of dressing. Superphosphate also gave a significant increase in yield, the falling off in response at the higher level of dressing not being significant. There was a positive interaction between the effects of sulphate of ammonia and superphosphate, the response to each being significantly greater with the double dressing of the other than with the zero dressing. The effects of potash were not significant.

The effects of the treatments on plant number were similar to those on yield. The effects on yield cannot, however, be considered simply as a reflection of those on plant number and persist after eliminating the effect of plant number on yield.

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Potatoes—W. E. Morton, Esq., Australia Farm, March, 1935

3 randomised blocks of 9 plots each, certain second order interactions being confounded with block differences. Plots : 1/60 acre.

TREATMENTS : All combinations of :

$$\text{Sulph. amm.}\begin{Bmatrix}\text{None}\\ \text{0.3 cwt. N}\\ \text{0.6 cwt. N}\end{Bmatrix} \times \text{Super.}\begin{Bmatrix}\text{None}\\ \text{0.75 cwt. } P_2O_5\\ \text{1.50 cwt. } P_2O_5\end{Bmatrix} \times \text{Sulph. pot.}\begin{Bmatrix}\text{None}\\ \text{0.75 cwt. } K_2O\\ \text{1.50 cwt. } K_2O\end{Bmatrix}$$

BASAL MANURING : Nil.

SOIL : Good quality Fenland, near the clay. Variety : Majestic. Manures applied : Apr. 2. Potatoes planted : Apr. 18. Lifted : Nov. 13. Previous crop : Wheat.

SPECIAL NOTE : 1 cwt. of potatoes from each plot was passed over a $1\frac{5}{8}$ inch riddle to determine the percentage ware.

STANDARD ERRORS PER PLOT : Total produce : 0.941 tons per acre or 13.8%. Percentage ware : 4.27.

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 (±0.543. *Means: ±0.314. Increases: ±0.444.*)								
0.0 cwt. N. ..	4.72	5.28	5.71	5.17	6.25	4.28	*5.23*	
0.3 cwt. N. ..	6.46	7.35	7.30	7.28	6.93	6.90	*7.04*	*+1.81*
0.6 cwt. N. ..	7.26	8.17	8.95	7.69	8.35	8.34	*8.13*	*+1.09*
Mean	*6.15*	*6.93*	*7.32*	*6.71*	*7.18*	*6.51*	*6.80*	
Increase ..		*+0.78*	*+0.39*		*+0.47*	*−0.67*		
Percentage ware (±2.46. *Means: ±1.42. Increases: ±2.01*).								
0.0 cwt. N. ..	79.5	79.6	78.9	79.6	82.4	76.1	*79.4*	
0.3 cwt. N. ..	83.3	81.8	83.7	85.5	79.9	83.4	*82.9*	*+3.5*
0.6 cwt. N. ..	84.3	83.4	86.8	84.0	84.3	86.2	*84.8*	*+1.9*
Mean	*82.4*	*81.6*	*83.1*	*83.0*	*82.2*	*81.9*	*82.4*	
Increase ..		*−0.8*	*+1.5*		*−0.8*	*−0.3*		

Interaction of superphosphate with sulphate of potash.

Sulphate of potash	Total produce: tons per acre (±0.543) Superphosphate (cwt. P_2O_5) 0.00	0.75	1.50	Percentage ware (±2.46) Superphosphate (cwt. P_2O_5) 0.00	0.75	1.50
0.00 cwt. K_2O ..	5.72	6.85	7.57	84.6	81.2	83.3
0.75 cwt. K_2O ..	6.35	7.92	7.27	80.8	83.7	82.1
1.50 cwt. K_2O ..	6.37	6.03	7.12	81.8	79.9	84.0

Conclusions

Sulphate of ammonia produced significant increases in both yield and percentage ware, the falling-off in response at the higher level of dressing not being significant. Superphosphate significantly increased the yield. There were no significant responses to potash.

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Potatoes—G. Major, Esq., Newton Farm, Tydd, Wisbech, 1935

3 randomised blocks of 9 plots each, certain second order interactions being confounded with block differences. Plots : 1/60 acre.

TREATMENTS : All combinations of :

Sulph. amm. {None, 0.4 cwt. N, 0.8 cwt. N} × Super. {None, 0.7 cwt. P_2O_5, 1.4 cwt. P_2O_5} × Sulph. pot. {None, 1.0 cwt. K_2O, 2.0 cwt. K_2O}

BASAL MANURING : 10 loads dung per acre.

SOIL : Deep silt. Variety : King Edward. Manures applied : Mar. 19th. Potatoes planted : Apr. 6. Lifted : Oct. 30. Previous crop : Peas.

STANDARD ERROR PER PLOT : 1.04 tons per acre or 9.83%.

Main effects—Interactions of sulphate of ammonia with superphosphate and sulphate of potash.

Total Produce : tons per acre (±0.600. *Means : ±0.346. Increases : ±0.489)*

Sulphate of ammonia	Superphosphate (cwt. P_2O_5) 0.0	0.7	1.4	Sulphate of potash (cwt. K_2O) 0.0	1.0	2.0	*Mean*	*Increase*
0.0 cwt. N.	10.10	11.54	9.51	10.34	10.58	10.23	*10.38*	
0.4 cwt. N.	10.52	10.09	11.40	10.71	11.04	10.25	*10.67*	*+0.29*
0.8 cwt. N.	10.03	11.43	10.84	10.20	11.73	10.36	*10.76*	*+0.09*
Mean ..	*10.22*	*11.02*	*10.58*	*10.42*	*11.12*	*10.28*	*10.60*	
Increase ..		*+0.80*	*−0.44*		*+0.70*	*−0.84*		

Interaction of superphosphate with sulphate of potash.

Total Produce : tons per acre (±0.600)

Sulphate of potash	Superphosphate (cwt. P_2O_5) 0.0	0.7	1.4
0.0 cwt. K_2O ..	9.90	11.12	10.24
1.0 cwt. K_2O ..	10.31	11.78	11.27
2.0 cwt. K_2O ..	10.43	10.17	10.24

Conclusions

No significant effects. Farmyard manure was sufficient in a year of unusual drought.

Potatoes. J. Morris, Esq., Honey Farm, Wimblington, Cambs., 1935

4 randomised blocks of 8 plots each. Third order interaction confounded.

PLOTS : 1/60 acre.

TREATMENTS : All combinations of :

Sulph. amm. {None, 0.5 cwt. N} × Super. {None, 1.0 cwt. P_2O_5} × Sulph. Pot. {None, 1.25 cwt. K_2O} × Dung {None, 8½ tons}

BASAL MANURING : Nil.

SOIL : Light fenland resting on peat. Variety : Majestic. Manures applied : April 23. Seed sown April 25. Potatoes lifted : October 29. Previous crop : Carrots.

SPECIAL NOTE : Potatoes passed over a 1⅝ inch riddle to determine percentage ware.

STANDARD ERRORS PER PLOT : Total produce : 0.573 tons per acre or 8.02% ; percentage ware : 6.36.

Mean Yields : TOTAL PRODUCE, *7.14 tons* : PERCENTAGE WARE, *73.3*.

	Mean response	Differential responses							
		Sulph. Amm.		Super.		Sulph. Pot.		Dung	
		Absent	Present	Absent	Present	Absent	Present	Absent	Present
		TOTAL PRODUCE ; tons per acre							
Sulph.Amm.	*+0.95*	—	—	+0.96	+0.95	+0.80	+1.10	+0.65	+1.26
Super.	*+0.47*	+0.47	+0.47	—	—	+0.40	+0.54	+0.49	+0.45
Sulph.Pot.	*+1.20*	+1.05	+1.36	+1.13	+1.28	—	—	+2.43	−0.03
Dung	*+2.47*	+2.16	+2.77	+2.49	+2.45	+3.70	+1.24	—	—
St. Errors	*±0.202*	±0.286							
		PERCENTAGE WARE							
Sulph.Amm.	*−0.4*	—	—	−2.1	+1.3	−0.2	−0.6	+2.4	−3.2
Super.	*+4.5*	+2.8	+6.2	—	—	+1.4	+7.6	+4.5	+4.5
Sulph. Pot.	*+9.1*	+9.4	+8.9	+6.0	+12.2	—	—	+22.2	−3.9
Dung	*+16.6*	+19.5	+13.8	+16.6	+16.6	+29.7	+3.6	—	—
St. Errors	*±2.25*	±3.18							

Conclusions

All four treatments gave significant responses in yield and all except sulphate of ammonia significantly increased percentage ware. The increases to sulphate of potash, however, both in yield and percentage ware, occurred only in the absence of dung, the interactions between sulphate of potash and dung being significant.

Sugar Beet. Tunstall, Suffolk, 1935. A. W. Oldershaw, Esq., County Organiser

5 × 5 Latin Square. Plots : 1/56 acre.
TREATMENTS : Fourth year, no further chalk applied (see 1932 Report, p. 208, for first year's dressings.)
BASAL MANURING : 3 cwt. superphosphate, 3 cwt. potash salt and 3 cwt. nitrate of lime per acre.
SOIL : Poor sand. Variety : Kleinwanzleben E. Basal manures applied : Minerals, Apr. 16 ; Nitrogen, May 6. Seed sown : May 6. Harvested : Nov. 14. Previous crop : Sugar Beet.
STANDARD ERRORS PER PLOT : Roots (washed) 0.540 tons per acre or 3.49%. Tops : 0.416 tons per acre or 4.19%. Sugar percentage : 0.0824. Mean dirt tare : 0.1217.

Chalk tons per acre (1932)	ROOTS (washed) Tons per acre.	*Increase*	TOPS Tons per acre.	*Increase*	SUGAR PERCENTAGE	*Increase*	TOTAL SUGAR Cwt. per acre.	*Increase*
Mean	*15.48*		*9.93*		*17.46*		*54.0*	
0*	Nil		Nil		—		Nil	
1	14.64		9.44		17.39		50.9	
2	15.90	*+1.26*	9.68	*+0.24*	17.56	*+0.17*	55.8	*+4.9*
3	15.43	*−0.47*	10.22	*+0.54*	17.52	*−0.04*	54.1	*−1.7*
4	15.97	*+0.54*	10.39	*+0.17*	17.36	*−0.16*	55.4	*+1.3*
St. errors	±0.242	*±0.342*	±0.186	*±0.263*	±0.0368	*±0.0520*		

* NOTE : The plots receiving no chalk in 1932 gave negligible yields.

Conclusions

There was a significant response in roots to the second (1932) dressing of lime over the first, but no further response to the higher dressings. In tops there was a significant response, which showed no sign of falling off at the higher dressings. The second and third dressings gave a significantly higher sugar percentage than the first and fourth dressings.

Celery. A. S. Rickwood, Esq., Mepal, Isle of Ely, 1935.

6 blocks of 4 plots each. Second order interaction confounded. Plots : 1/100 acre.

TREATMENTS : All combinations of :

Superphosphate. { None, 5 cwt. } × Muriate of Potash. { None, 3 cwt. } × Salt. { None, 5 cwt. }

BASAL MANURING : 13 tons of dung.

SOIL : Light fen. Manures applied : May 30. Planted : 1st week in June, drills 4 ft. 6 ins. apart, plants 4 ins. apart in the rows. Harvested : March 18, 1936. Previous crop : Wheat.

SPECIAL NOTE : The celery was divided on the field into five grades, according to the number of heads which could be packed in a crate. The mean grade was determined by assigning values 2, 1, 0, −1, −2 to the five grades, 2 being the top grade.

STANDARD ERRORS PER PLOT : Total yield : 0.354 tons per acre or 4.26%. Mean grade : 0.0989.

	Sub-blocks A.				Sub-blocks B.					
	None	Super and Salt	Super and Mur. Pot.	Mur. Pot. and Salt	Super	Mur. Pot.	Salt	Super Mur. Pot. Salt	*Mean*	Standard Error
Yield—tons per acre	7.28	8.43	8.68	8.87	7.91	8.56	7.89	8.96	*8.32*	±0.204
Mean Grade ..	0.583	0.754	0.682	0.905	0.503	0.709	0.538	0.724	*0.675*	±0.0571

Responses to fertilisers

Treatment	*Mean Response*	Superphosphate Absent	Superphosphate Present	Muriate of Pot. Absent	Muriate of Pot. Present	Salt Absent	Salt Present
TOTAL YIELD : tons per acre (±0.204. *Means : ±0.144*)							
Superphosphate ..	*+0.34*	—	—	+0.58	+0.10	+0.37	+0.32
Muriate of Potash ..	*+0.89*	+1.13	+0.65	—	—	+1.02	+0.76
Salt	*+0.43*	+0.46	+0.40	+0.56	+0.30	—	—
MEAN GRADE : (±0.0571. *Means : ±0.0404*)							
Superphosphate ..	*−0.018*	—	—	+0.068	−0.104	−0.054	+0.018
Muriate of Potash ..	*+0.160*	+0.246	+0.074	—	—	+0.152	+0.168
Salt	*+0.111*	+0.076	+0.146	+0.103	+0.119	—	—

Conclusions

All three fertilisers produced significant increases in the yield of heads. Muriate of potash and salt also produced significant increases in the size of heads, as measured by the mean grade, but superphosphate had no apparent effect on size.

EXPERIMENTS CARRIED OUT BY LOCAL WORKERS

Hay—3rd Season. H. W. Gardner, Esq., Hertfordshire Farm Institute, St. Albans, 1935

5 randomised blocks of 6 plots each. Plots : 1/50 acre.

TREATMENTS : All combinations of :

{No phosphate; Basic slag (15% P_2O_5, 85% citric solubility); Gafsa phosphate (90% through 120 sieve)} × {No potash; 30% potash salt (0.5 cwt. K_2O)}

Phosphates at the rate of 1.0 cwt. P_2O_5 per acre. The manures were applied in 1933.

BASAL MANURING : Nil.

SOIL : Heavy flinty loam, well supplied with chalk. Manures applied : Jan. 7th, 1933. Cut : July 1st.

STANDARD ERROR PER PLOT : 1.41 cwt. per acre or 3.88%.

Cwt. per acre (±0.631)	No phosphate	Basic slag	Mineral phosphate	*Mean* (±*0.364*)	*Increase* (±*0.515*)
No potash	34.2	37.1	37.2	*36.2*	
Potash	34.7	37.0	37.2	*36.3*	*+0.1*
Mean (±*0.446*)	*34.4*	*37.0*	*37.2*	*36.2*	
Incr. (±*0.631*)		*+2.6*	*+0.2*		

Conclusions

There was a significant response to phosphate (applied in 1933) of 2.7 cwt. per acre, but no sign of any difference between the two qualities of phosphate. There was no sign of response to potash (also applied in 1933).

Hay—2nd Season. Rowley Green Farm, Arkeley, Barnet, Herts, 1935 H. W. Gardner, Esq., Hertfordshire Farm Institute

6 randomised blocks of 6 plots each. Certain interactions partially confounded with block differences.

PLOTS : 1/50 acre.

TREATMENTS : All combinations of :

{None; High soluble slag (1 cwt. P_2O_5) per acre; Gafsa phosphate (1 cwt. P_2O_5) per acre} × {None; 30% potash salt (0.5 cwt. K_2O) per acre.} × {None; 75 cwt. chalk}

These treatments were applied in 1934.

BASAL MANURING : Nil.

SOIL : Acid clay. Chalk applied : Jan. 30th, 1934. Minerals applied : Feb. 6th, 1934. Hay cut : July 4th.

STANDARD ERROR PER PLOT : 2.33 cwt. per acre or 8.10%.

Responses to Fertilisers applied in 1934 : cwt. per acre.

Mean yield: 28.8 cwt.

	Mean response	Differential responses						
		Chalk Absent	Chalk Present	Potash Absent	Potash Present	No phos.	Slag	Gafsa phos.
Chalk	*+5.4*[1]	—	—	+5.2[3]	+5.6[3]	+6.2[4]	+3.8[4]	+6.1[4]
Potash	*−0.4*[1]	−0.6[3]	−0.2[3]	—	—	−0.1[4]	−1.1[4]	+0.1[4]
Slag	*0.0*[2]	+1.2[4]	−1.2[4]	+0.5[4]	−0.5[4]	—	—	—
Gafsa phosphate	*−0.9*[2]	−0.8[4]	−0.9[4]	−1.0[4]	−0.8[4]	—	—	—

Standard errors : (1) ±0.777, (2) ±0.951, (3) ±1.17, (4) ±1.35.

Conclusions

There was a significant response to chalk applied in 1934.

Hay. 5th Season. Lady Manner's School, Bakewell, 1935

3 randomised blocks of 8 plots each.
PLOTS : 1/161 acre.
TREATMENTS : All combinations of :
{None / 2 cwt. nitrate of soda} × {None / 3 cwt. superphosphate} × {None / 1 cwt. 30% potash salt}
BASAL MANURING : Nil.
SOIL : Limestone. Manures applied : March 15-22. Hay cut : July 3-4.
STANDARD ERROR PER PLOT : 6.24 cwt. per acre, or 13.4%.

Yields of Individual Treatments: cwt. per acre.

O	N	P	K	NP	NK	PK	NPK	*Mean*
37.4	47.3	42.5	37.4	49.7	53.5	42.6	61.9	46.5

Responses to Fertilisers: cwt. per acre.

Fertiliser	*Mean Response* (±*2.55*)	Differential Responses (±3.60)					
		Nitrate of Soda		Superphosphate		Potash salt	
		Absent	Present	Absent	Present	Absent	Present
Nitrate of Soda ..	+*13.1*	—	—	+13.0	+13.2	+8.6	+17.7
Superphosphate ..	+*5.3*	+5.2	+5.4	—	—	+3.8	+6.8
Potash salt	+*4.6*	0.0	+9.2	+3.1	+6.2	—	—

Conclusions

There was a large response to nitrate of soda, and a significant response to potash salt in the presence of nitrate of soda. The response to superphosphate was not quite significant.

Meadow Hay. 4th Season. Lady Manner's School, Bakewell, 1935.

4 randomised blocks of 9 plots each.
PLOTS : 1/216 acre.
TREATMENTS : All combinations of :
{No manure / 8 tons of Compost / Mixed Artificials} Applied in 1933 and 1935 × {No manure / 8 tons of Compost / Mixed Artificials} Applied in 1932 and 1934

Mixed artificials consisted of 2 cwt. nitrate of soda, 3 cwt. superphosphate, and 1 cwt 30% potash salt per acre.
BASAL MANURING : Nil.
SOIL : Limestone. Manures applied : March 22. Hay cut : July 11.
STANDARD ERROR PER PLOT : 4.84 cwt. per acre or 10.9%.

Summary; cwt. per acre (±2.42)

1933 and 1935 treatments	1932 and 1934 treatments Nil	NPK	Compost	*Mean* (±*1.40*)	*Increase* (±*1.98*)
Nil	31.4	34.2	41.1	*35.6*	
NPK	50.3	48.7	54.1	*51.0*	+*15.4*
Compost ..	45.6	40.9	52.2	*46.2*	+*10.6*
Mean (±*1.40*) ..	*42.4*	*41.3*	*49.1*	*44.3*	
Increase (±*1.98*)		−*1.1*	+*6.7*		

Conclusions

The 1935 treatments both gave large increases in yield, the increase to complete artificials being significantly greater than that to compost. Of the 1934 treatments, however, compost gave a significant increase, but complete artificials a small, though not significant, decrease.

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Hay (3rd Season) Cavendish Lodge, Clipstone, Mansfield, 1935.

R. N. Dowling, Esq., County Organiser.

The experiment began in 1933 on Sugar Beet and was continued in 1934 on Oats.

6 randomised blocks of 9 plots each.

PLOTS : 1/160 acre.

TREATMENTS : All combinations of :

$$\text{Mur. pot.}\left\{\begin{matrix}\text{None}\\ 1\tfrac{1}{2}\text{ cwt.}\\ 3\text{ cwt.}\end{matrix}\right\} \times \text{Limestone}\left\{\begin{matrix}\text{None}\\ 30\text{ cwt.}\\ 60\text{ cwt.}\end{matrix}\right\}$$

BASAL MANURING : Nil.

SOIL : Sandy gravel from Bunter Drift; very acid. Manures applied : Potash : March 20, 1935, Limestone to sugar beet in April, 1933. Hay cut : July 1. Previous crop : Oats.

STANDARD ERROR PER PLOT : 1.32 cwt. per acre or 9.64%.

Hay: cwt. per acre (±0.539)

Muriate of Potash	Limestone (cwt. per acre) None	30	60	*Mean* (±*0.311*)	*Increase* (±*0.440*)
None ..	13.1	13.1	14.3	*13.5*	
1½ cwt. ..	12.6	13.1	14.8	*13.5*	*0.0*
3 cwt. ..	13.8	14.5	14.0	*14.1*	+*0.6*
Mean (±*0.311*)	*13.2*	*13.6*	*14.4*	*13.7*	
Incr. (±*0.440*)		+*0.4*	+*0.8*		

Conclusions

There was a significant increase to limestone. The increase to muriate of potash was not significant.

Hay—Lower Tidmore Green Farm, Stevenage, 1935

H. W. Gardner, Esq., Hertfordshire Farm Institute

5×5 Latin square. Plots : 0.01443 acre.

TREATMENTS : Chalk at the rate of 0, 35, 70, 140, 210 cwt. per acre.

BASAL MANURING : Nil.

SOIL : Gravelly loam. Chalk applied : May 30th, 1933. Cut : June 24th. Previous crop : Winter oats.

STANDARD ERROR PER PLOT : 6.04 cwt. per acre or 11.4%.

Chalk cwt. per acre	Yield cwt. per acre	Increase for each dressing
Mean	*52.8*	
None	25.5	
35	46.0	+20.5
70	59.2	+13.2
140	66.0	+6.8
210	67.3	+1.3
St. error	±2.70	±3.82

Conclusions

There was a large response to liming, with a significant falling off in response at the higher levels, the additional responses to the two highest dressings not being individually significant.

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Wheat. H. W. Gardner, Esq., Hertfordshire Farm Institute, St. Albans, 1935.

3 randomised blocks of 9 plots each. Plots : 1/112 acre.
TREATMENTS : 0, 0.5 cwt. and 1.0 cwt. of P_2O_5 as superphosphate, basic slag and mineral phosphate.
BASAL MANURING : 2 cwt. Chilean potash nitrate per acre.
SOIL : Loamy. Variety : Victor. Seed sown : Nov. 5. Manures applied : Nov. 21. Harvested : Aug. 7. Previous crop : Potatoes.
STANDARD ERRORS PER PLOT : Grain : 2.43 cwt. per acre or 9.81%. Straw : 9.75 cwt. per acre or 17.9%.

	GRAIN : cwt. per acre (±1.40)					STRAW : cwt. per acre (±5.63)				
	Super	Basic slag	Mineral phos-phate	*Mean*	*Increase*	Super	Basic slag	Mineral phos-phate	*Mean*	*Increase*
0.0 cwt. P_2O_5		26.3[1]		*26.3*[1]			54.5[5]		*54.5*[5]	
0.5 cwt. P_2O_5	21.5	22.3	24.8	*22.9*[1]	*−3.4*[3]	51.9	57.2	56.4	*55.2*[5]	*+0.7*[7]
1.0 cwt. P_2O_5	23.5	28.0	23.9	*25.1*[1]	*+2.2*[3]	50.6	51.7	59.3	*53.9*[5]	*−1.3*[7]
Mean	*22.5*[2]	*25.2*[2]	*24.4*[2]	*24.8*		*51.2*[6]	*54.4*[6]	*57.8*[6]	*54.5*	
Increase		*+2.7*[4]	*+1.9*[4]				*+3.2*[8]	*+6.6*[8]		

STANDARD ERRORS : (1) ±0.808, (2) ±0.990, (3) ±1.14, (4) ±1.40, (5) ±3.25, (6) ±3.98, (7) ±4.60, (8) ±5.63.

Conclusions

The mean yields of the separate treatments are more irregular than expectation but do not lead to any consistent conclusions.

Potatoes. The Senior School, Cadishead, Lancs., 1935

5 randomised blocks of 3 plots each. Plots : 1/242 acre.
TREATMENTS : No phosphate, basic slag (11.8% P_2O_5, 78% citric solubility) and superphosphate both at the rate of 0.8 cwt. P_2O_5.
BASAL MANURING : Sulphate of ammonia at the rate of 0.6 cwt. N and sulphate of potash at the rate of 1.5 cwt. K_2O.
SOIL : Rather heavy, rich in organic matter. On the edge of Chat Moss. Variety : Arran Banner. Manures applied : March 15, May 3. Potatoes planted : May 10. Lifted : September 12-13. Previous crop : Potatoes.
SPECIAL NOTE : Potatoes sorted by hand.
STANDARD ERRORS PER PLOT : Total produce : 0.902 tons per acre or 22.8%. Percentage ware : 7.60.

	Total Produce		Percentage Ware	
	Tons per acre	*Increase over no dressing*		*Increase over no dressing*
Mean	*3.95*		*71.9*	
None ..	3.63		63.3	
Basic slag	3.35	*−0.28*	70.8	*+7.5*
Super ..	4.88	*+1.25*	81.6	*+18.3*
St. Errors	±0.403	*±0.570*	±3.40	*±4.81*

Conclusions

Superphosphate gave a significant increase in yield and basic slag a small but not significant decrease. Both treatments increased percentage ware, the increase due to superphosphate being large and significantly greater than that due to basic slag, which was not itself significant.

Potatoes. Midland Agricultural College, Loughborough, 1935.

4 randomised blocks of 9 plots each. Plots: 1/48.8 acre.

TREATMENTS: All combinations of :—

{None, 1½ cwt. sulph. amm., 3 cwt. sulph. amm.} × {None, 1½ cwt. sulph. pot., 3 cwt. sulph. pot.}

BASAL MANURING: Superphosphate at the rate of 3 cwt. per acre and a dressing of lime and farmyard manure.

SOIL: Light loam. Variety: King Edward. Manures applied: April 11. Potatoes planted: Apr. 23. Lifted: Oct .14. Previous crop: Seeds hay.

STANDARD ERRORS PER PLOT: Total produce: 0.967 tons per acre or 11.3%. Percentage ware: 5.92.

Sulphate of Potash (cwt.)	Sulphate of Ammonia (cwt.) None	1½	3	*Mean*	*Increase*
TOTAL PRODUCE: tons per acre (±0.484. *Means*: ±*0.279*. *Increases*: ±*0.394*)					
None	8.71	8.51	8.57	*8.60*	
1½ ..	8.34	7.89	8.48	*8.24*	*—0.36*
3 ..	8.87	8.72	8.77	*8.79*	*+0.55*
Mean ..	*8.64*	*8.37*	*8.61*	*8.54*	
Increase ..		*—0.27*	*+0.24*		
PERCENTAGE WARE: (±2.96. *Means*: ±*1.71*. *Increases*: ±*2.42*).					
None ..	65.6	66.4	69.4	*67.1*	
1½ ..	69.7	68.3	72.3	*70.1*	*+3.0*
3 ..	69.0	71.3	71.7	*70.7*	*+0.6*
Mean ..	*68.1*	*68.7*	*71.1*	*69.3*	
Increase ..		*+0.6*	*+2.4*		

Conclusions

No significant effects.

Potatoes. Midland Agricultural College, Loughborough, 1935.

4×4 Latin square. Plots: 1/48.8 acre.

TREATMENTS: 4 levels of a mixed fertiliser containing 1 part of sulphate of ammonia, 3 parts of superphosphate and 1 part of sulphate of potash.

BASAL MANURING: Farmyard manure.

SOIL: Light loam. Variety: King Edward. Manures applied: Apr. 12. Potatoes planted: Apr. 23. Lifted: Oct. 15. Previous crop: Seeds hay.

STANDARD ERRORS PER PLOT: Total produce: 0.710 tons per acre or 9.00%. Percentage ware 9.17.

Artificials	Yield tons per acre	*Increase for each dressing*	Percentage ware	*Increase for each dressing*
Mean ..	*7.90*		*75.1*	
None ..	7.83		76.6	
4 cwt. ..	8.02	*+0.19*	76.2	*—0.4*
8 cwt. ..	7.79	*—0.23*	73.1	*—3.1*
12 cwt. ..	7.94	*+0.15*	74.6	*+1.5*
St. Errors ..	±0.355	±*0.502*	±4.58	±*6.48*

Conclusions

No significant effects.

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https://doi.org/10.23637/ERADOC-1-67

Potatoes. Messrs. Cheeseman, Bros., Catchwater, Messingham, Lincs, 1935. A. McVicar, Esq., County Organiser.

5×5 Latin square. Plots : 1/80 acre.

TREATMENTS : Increasing levels of a mixed fertiliser (6 parts sulphate of ammonia, 6 parts superphosphate, 5 parts sulphate of potash, 1 part steamed bone flour) as shown.

BASAL MANURING : Farmyard manure.

SOIL : Sand. Variety : Majestic. Manures applied : April 8. Potatoes planted : April 9. Lifted : Oct. 25. Previous crop : permanent pasture.

SPECIAL NOTE : Potatoes passed over a 1⅝ inch riddle to determine the percentage ware.

STANDARD ERRORS PER PLOT : Total produce : 0.847 tons per acre or 10.5%. Percentage ware : 4.34.

Mixed Fertiliser cwt. per acre	Total produce tons per acre	*Increase*	Percentage ware	*Increase*
Mean	*8.08*		*76.3*	
0	5.26		72.5	
4	6.88	*+1.62*	76.6	*+4.1*
8	8.70	*+1.82*	77.6	*+1.0*
12	9.74	*+1.04*	78.7	*+1.1*
16	9.81	*+0.07*	76.3	*−2.4*
St. Errors ..	±0.379	*±0.536*	±1.94	*±2.74*

Conclusions

There was a significant response in yield to the mixed fertiliser, with a significant drop in response at the higher levels. The effects on percentage ware were similar, but did not reach significance.

Potatoes. J. Wright, Esq., Grayingham, Lincs., 1935. A. McVicar, Esq., County Organiser.

5×5 Latin square. Plots : 1/80 acre.

TREATMENTS : Increasing levels of a mixed fertiliser (6 parts sulphate of ammonia, 6 parts superphosphate, 5 parts sulphate of potash, 1 part of steamed bone flour) as shown.

BASAL MANURING : Farmyard manure.

SOIL : Oolitic limestone. Variety : King Edward. Manures applied : April 6. Potatoes planted : April 8. Lifted : Oct. 22. Previous crop : Grazing seeds.

STANDARD ERROR PER PLOT : 0.885 tons per acre or 9.66%.

Mixed Fertiliser cwt. per acre	Total Produce	
	Tons per acre	*Increase*
Mean	*9.16*	
0	8.47	
4	9.03	*+0.56*
8	9.33	*+0.30*
12	9.31	*−0.02*
16	9.64	*+0.33*
St. Errors ..	±0.396	*±0.560*

Conclusions

The mixed fertiliser produced a significant increase in yield, the falling-off in response at the higher levels not being significant.

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Potatoes. Messrs. Temperton Bros., Kelfield, Owston Ferry, Lincs., 1935. A. McVicar, Esq., County Organiser.

4 × 4 Latin square. Plots : 1/80 acre.

TREATMENTS : Increasing levels of sulphate of potash as indicated in the table.

BASAL MANURING : Farmyard manure applied to wheat stubble, sulphate of ammonia at the rate of 4 cwt. per acre, superphosphate at the rate of 3 cwt. per acre.

SOIL : Warp. Variety : Majestic. Manures applied : April 1. Potatoes planted : April 2. Lifted : Oct. 30. Previous crop : Wheat.

STANDARD ERRORS PER PLOT : Total produce : 0.791 tons per acre or 7.43%. Percentage ware : 1.24.

Sulphate of potash Cwt. per acre	Total Produce Tons per acre	*Increase*	Percentage Ware	*Increase*
Mean	*10.64*		*88.6*	
0	9.14		86.7	
1	10.54	*+1.40*	89.6	*+2.9*
2	10.97	*+0.43*	88.4	*−1.2*
3	11.93	*+0.96*	89.6	*+1.2*
Standard Errors ..	±0.396	*±0.560*	±0.620	*±0.877*

Conclusions

There was a significant response in yield to sulphate of potash, the drop in response at the higher level of dressing not being significant. The first dressing produced a significant increase in percentage ware, but there was no further increase to the higher dressings.

Sugar Beet. A. E. Bird, Esq., Scotter, Gainsborough, 1935 Bardney and Brigg Sugar Factory A. McVicar, Esq., County Organiser.

4 × 4 Latin square. Plots : 1/40 acre.

TREATMENTS : 4 widths of singling 6, 9, 12 and 15 inches.

BASAL MANURING : 10 cwt. per acre compound fertiliser.

SOIL : Light loam. Variety : Kleinwanzleben E. Seed sown : April 20. Lifted : October 25. Previous crop : Wheat.

STANDARD ERRORS PER PLOT : Roots (washed) : 0.541 tons per acre or 4.84%. Tops : 0.303 tons per acre or 4.65%. Mean dirt tare : 0.1010.

Singling Inches	ROOTS (washed) Tons	*Increase*	TOPS Tons	*Increase*	SUGAR PERCENTAGE	*Increase*	TOTAL SUGAR Cwt.	*Increase*	PLANT NUMBER Thousands	*Increase*
Mean ..	*11.18*		*6.52*		*18.36*		*41.0*		*35.0*	
6 ..	11.15		6.74		18.34		40.9		46.6	
9 ..	11.46	*+0.31*	6.50	*−0.24*	18.26	*−0.08*	41.8	*+0.9*	37.3	*−9.3*
12 ..	11.34	*−0.12*	6.64	*+0.14*	18.50	*+0.24*	42.0	*+0.2*	30.2	*−7.1*
15 ..	10.75	*−0.59*	6.20	*−0.44*	18.36	*−0.14*	39.5	*−2.5*	25.8	*−4.4*
St. Errors	±0.270	*±0.382*	±0.152	*±0.215*						

Conclusions

The effects on the yields of roots of varying the width of singling were not significant. The yield of tops, however, decreased significantly as the width of singling increased.

Sugar Beet. E. W. Bowser, Esq., Boston, 1935
Bardney and Brigg Sugar Factory
A. McVicar, Esq., County Organiser.

4×4 Latin square. Plots : 1/40 acre.

TREATMENTS : 4 widths of singling : 6, 9, 12 and 15 inches.

BASAL MANURING : Nil.

SOIL : Fen. Variety : Kuhn P. Seed sown : April 29. Lifted : October 31. Previous crop : Potatoes.

SPECIAL NOTE : Tops were weighed on 12 plots only.

STANDARD ERRORS PER PLOT : Roots (washed) : 0.713 tons per acre or 4.79% ; tops : 0.882 tons per acre or 3.70%. Mean dirt tare : 0.1897.

Inches	ROOTS (washed) Tons	*Increase*	TOPS Tons	*Increase*	SUGAR PERCENTAGE	*Increase*	TOTAL SUGAR cwt.	*Increase*	PLANT NUMBER Thousands	*Increase*
Mean	*14.88*		*23.81*		*13.73*		*40.8*		*31.0*	
6 ..	15.30		25.01		14.02		42.9		41.0	
9 ..	14.49	*−0.81*	23.91	*−1.10*	13.40	*−0.62*	38.8	*−4.1*	33.5	*−7.5*
12 ..	14.82	*+0.33*	23.15	*−0.76*	13.80	*+0.40*	40.9	*+2.1*	27.5	*−6.0*
15 ..	14.90	*+0.08*	23.18	*+0.03*	13.70	*−0.10*	40.8	*−0.1*	22.2	*−5.3*
St. Errors	±0.356	*±0.503*	±0.180	*±0.254*						

Conclusions

No significant effects on roots. The yield of tops decreased significantly from the 6 to the 9-inch singling and from the 9 to the 12-inch singling.

Sugar Beet. G. Wardell, Esq., Snitterby, 1935
Bardney and Brigg Sugar Factory
A. McVicar, Esq., County Organiser.

4 randomised blocks of 8 plots each. Certain interactions partially confounded with block differences. Plots : 1/40 acre.

TREATMENTS : All combinations of :

$$\text{Mixed artificials}\begin{Bmatrix}\text{None}\\ \text{4 cwt.}\\ \text{8 cwt.}\\ \text{12 cwt.}\end{Bmatrix}\times\ \text{Nitrate of soda (top dressing)}\begin{Bmatrix}\text{None}\\ \text{1 cwt.}\end{Bmatrix}\times\ \text{Time of lifting}\begin{Bmatrix}\text{Early (Oct. 21-22)}\\ \text{Late (Nov. 25-26)}\end{Bmatrix}$$

The mixed artificials consisted of 3½ parts sulphate of ammonia, 3 parts nitrate of soda, 6½ parts granulated superphosphate (18% P_2O_5), 4 parts muriate of potash, and 1 part steamed bone flour.

BASAL MANURING : Nil.

SOIL : Limestone loam. Variety : Kleinwanzleben E. Manures applied : April 17. Seed sown : May 3. Previous crop : Wheat.

STANDARD ERRORS PER PLOT : Roots (washed) : 0.792 tons per acre or 6.77% ; tops : 0.781 tons per acre or 10.2% ; mean dirt tare : first lifting : 0.1971, second lifting : 0.2235.

Nitrate of Soda	ROOTS (washed) tons per acre Early	Late	*Mean*	*Incr.*	TOPS tons per acre Early	Late	*Mean*	*Incr.*	SUGAR PERCENTAGE Early	Late	*Mean*	*Incr.*
None ..	10.85[1]	11.60[1]	*11.22*[2]		8.49[1]	5.41[1]	*6.95*[2]		18.00	17.04	*17.52*	
1 cwt.	11.80[1]	12.55[1]	*12.18*[2]	*+0.96*[1]	10.27[1]	6.40[1]	*8.34*[2]	*+1.39*[1]	17.75	16.67	*17.21*	*−0.31*
Mean ..	*11.32*[2]	*12.08*[2]	*11.70*		*9.38*[2]	*5.90*[2]	*7.64*		*17.88*	*16.86*	*17.37*	
Incr. ..		*+0.76*[1]				*−3.48*[1]				*−1.02*		
St. Errors	(1) ±0.280	(2) ±0.198			(1) ±0.276	(2) ±0.195						

	TOTAL SUGAR cwt. per acre				PLANT NUMBER thous. per acre				PERCENTAGE PURITY			
None ..	39.0	39.5	*39.2*		27.2	25.5	*26.4*		88.8	87.8	*88.3*	
1 cwt. ..	41.9	41.8	*41.8*	*+2.6*	27.5	25.5	*26.5*	*+0.1*	88.8	87.6	*88.2*	*−0.1*
Mean ..	*40.4*	*40.6*	*40.5*		*27.4*	*25.5*	*26.4*		*88.8*	*87.7*	*88.2*	
Incr. ..		*+0.2*				*−1.9*				*−1.1*		

	Mixed artificials: cwt. per acre 0	4	8	12	Mixed artificials: cwt. per acre 0	4	8	12
	ROOTS (washed): tons per acre (±0.396)				TOPS: tons per acre (±0.390)			
No N/S	10.23	10.91	11.88	11.87	5.54	6.28	7.10	8.87
N/S	10.86	12.16	12.66	13.03	6.77	7.95	8.95	9.66
Early	10.65	10.72	11.80	12.12	7.69	8.47	10.00	11.36
Late	10.44	12.34	12.75	12.77	4.62	5.76	6.04	7.18
Mean	*10.54*[1]	*11.53*[1]	*12.27*[1]	*12.45*[1]	*6.16*[1]	*7.12*[1]	*8.02*[1]	*9.27*[1]
Increase ..		*+0.99*[2]	*+0.74*[2]	*+0.18*[2]		*+0.96*[2]	*+0.90*[2]	*+1.25*[2]
St. Errors ..	(1) ±0.280 (2) ±0.396				(1) ±0.276 (2) ±0.390			
	SUGAR PERCENTAGE				TOTAL SUGAR: cwt. per acre			
No N/S ..	17.80	17.56	17.36	17.36	36.4	38.2	41.2	41.2
N/S	17.15	17.43	17.46	16.79	37.2	42.2	44.2	43.6
Early	17.84	18.02	18.03	17.60	37.9	38.6	42.5	42.7
Late	17.11	16.97	16.80	16.54	35.7	41.8	42.8	42.1
Mean	*17.48*	*17.50*	*17.41*	*17.07*	*36.8*	*40.2*	*42.7*	*42.4*
Increase ..		*+0.02*	*−0.09*	*−0.34*		*+3.4*	*+2.5*	*−0.3*
	PLANT NUMBER: thous. per acre				PERCENTAGE PURITY			
No N/S ..	25.8	26.6	27.2	26.0	88.5	88.4	88.4	87.8
N/S	25.8	25.9	26.4	27.9	88.4	88.4	88.1	87.9
Early	27.4	26.8	27.4	28.0	89.0	89.0	88.8	88.4
Late	24.3	25.8	26.2	25.8	88.0	87.8	87.7	87.3
Mean	*25.8*	*26.3*	*26.8*	*26.9*	*88.5*	*88.4*	*88.2*	*87.8*
Increase ..		*+0.5*	*+0.5*	*+0.1*		*−0.1*	*−0.2*	*−0.4*

Conclusions

Mixed artificials significantly increased the yields of roots and tops, the response falling off at the higher levels of dressing with roots, but not with tops. Nitrate of soda significantly increased the yields of roots and tops. Late lifting significantly increased the yield of roots and decreased the yield of tops. Late lifting also decreased the sugar percentage, and there was little difference between the yields of total sugar for the two times of lifting.

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Sugar Beet. R. J. Godfrey, Esq., Melton Ross, Barnetby, 1935
Bardney and Brigg Beet Sugar Factory.

4 × 4 Latin square. Plots : 1/160 acre.
TREATMENTS : (A) No treatment, (B) woody bolters pulled, (C) woody bolters pulled, others cut in July, (D) all bolters cut in July. Some of the beet which were cut in July did not again bolt.
BASAL MANURING : 12 cwt. mixture of artificials.
SOIL : Wold. Variety: Kleinwanzleben E. Seed sown : 1st week of April. Lifted : October 21. Previous crop : Wheat.
STANDARD ERROR PER PLOT : Total sugar : 2.08 cwt. per acre or 4.79%.

	Normal Beet	Woody Beet	Non-woody Beet	Cut and not bolted	Standard Error
Average weight per beet, lb. ..	1.28	0.79	1.30	1.18[1]	±0.034
Sugar per cent. ..	17.71	17.02	17.11	17.23[2]	±0.074

Standard Error ([1]) ±0.151, ([2]) ±0.325.

PLANT NUMBER : thousands per acre

Treatments	Normal Beet	Woody Beet	Non-woody Beet	Cut and not Bolted
A	18.6	4.5	2.7	—
B	14.7	2.8	2.3	—
C	17.2	2.4	1.8	0.8
D	17.9	3.6	2.0	0.9

TOTAL SUGAR : cwt. per acre

A	B	C	D	*Mean*	St. Error
42.2	41.6	45.0	44.7	*43.4*	±1.04

Conclusions

About a quarter of the beet bolted. Woody bolters weighed about one-third less than normal beet and the sugar percentage was also slightly lower, with a resultant loss of 40 per cent, in sugar on each woody bolter. There was little loss on non-woody bolters. Cutting in July produced a significant increase in total sugar of 3.0 cwt. per acre.

Sugar Beet. H. Windley, Esq., Tumby Wood Side, 1935
Bardney and Brigg Sugar Factory
A. McVicar, Esq., County Organiser.

4×4 Latin square. Plots 1/40 acre.

TREATMENTS : All combinations of sulphate of ammonia and nitro-chalk at the rate of 0.4 cwt. N per acre with superphosphate and basic slag at the rate of 0.55 cwt. P_2O_5 per acre.

BASAL MANURING : 3 cwt. 30% potash salt per acre.

SOIL : Sand on sandy subsoil. Variety : Strube. Manures applied : April 18. Seed sown : April 22. Lifted : Nov. 4. Previous crop : Oats.

STANDARD ERRORS PER PLOT : Roots (washed) : 0.260 tons per acre or 3.65% ; tops 0.432 tons per acre or 4.92%. Mean dirt tare : 0.1574.

	Sulph. amm.	Nitro-chalk	*Mean*	Sulph. amm.	Nitro-chalk	*Mean*
	ROOTS (washed) : tons per acre (±0.130. *Means* : ±*0.0919*)			TOPS : tons per acre : (±0.216. *Means* : ±*0.153*)		
Superphosphate ..	7.08	7.17	*7.12*	8.43	9.16	*8.80*
Basic Slag	7.06	7.22	*7.14*	8.85	8.69	*8.77*
Mean	*7.07*	*7.20*	*7.13*	*8.64*	*8.92*	*8.78*
	SUGAR PERCENTAGE			TOTAL SUGAR cwt. per acre		
Superphosphate ..	15.42	15.40	*15.41*	21.8	22.1	*22.0*
Basic Slag	15.50	15.38	*15.44*	21.9	22.2	*22.0*
Mean	*15.46*	*15.39*	*15.42*	*21.8*	*22.2*	*22.0*

PLANT NUMBER : thousands per acre

	Sulph. amm.	Nitro-chalk	*Mean*
Superphosphate	28.2	27.1	*27.6*
Basic Slag ..	27.5	28.2	*27.9*
Mean ..	*27.8*	*27.7*	*27.8*

Conclusions

No significant effects.

Sugar Beet. D. B. Sowerby, Esq., Kirmington, Ulceby, 1935
Bardney and Brigg Sugar Factory
A. McVicar, Esq., County Organiser.

5 × 5 Latin square. Plots : 1/40 acre.

Treatments : No manure (A), 1 cwt. superphosphate (B), 4 cwt. superphosphate, 1½ cwt. muriate of potash (C), 2 cwt. superphosphate (D), and 1 cwt. muriate of potash (E) per acre.

Basal Manuring : 1 cwt. sulphate of ammonia and 1½ cwt. nitrate of soda.

Soil : : Sandy loam on clay. Variety : Dippe. Manures applied : April 18. Seed sown : April 25. Lifted : Nov. 6. Previous crop : Wheat.

Standard Errors per Plot : Roots (washed) : 0.491 tons per acre or 4.05% ; tops : 0.531 tons per acre or 5.58%. Mean dirt tare : 0.1082.

	ROOTS (washed) Tons	*Increase*	TOPS Tons	*Increase*	SUGAR PERCENTAGE	*Increase*	TOTAL SUGAR Cwt.	*Increase*	PLANT NUMBER Thous.	*Increase*
Mean	*12.12*		*9.52*		*17.37*		*42.1*		*28.3*	
A	11.57		9.19		17.21		39.8		27.2	
B	12.16	+*0.59*	9.32	+*0.13*	17.47	+*0.26*	42.5	+*2.7*	28.5	+*1.3*
C	12.08	+*0.51*	9.84	+*0.65*	17.37	+*0.16*	42.0	+*2.2*	28.4	+*1.2*
D	12.68	+*1.11*	9.76	+*0.57*	17.41	+*0.20*	44.2	+*4.4*	29.1	+*1.9*
E	12.11	+*0.54*	9.48	+*0.29*	17.38	+*0.17*	42.1	+*2.3*	28.4	+*1.2*
St. Errors	±0.220	±*0.311*	±0.237	±*0.335*						

Conclusions

Significant response in roots to superphosphate.

Sugar Beet. The Lincolnshire Sugar Co., Ltd., Bardney and Brigg, 1935
F. Wakerley, Esq., County Organiser.

5×5 Latin square. Plots : 1/40 acre.

TREATMENTS : No manure, 1 cwt. of nitrate of soda, and 1 cwt. of nitrate of potash applied at time of seeding and singling.

BASAL MANURING : Nil (after autumn-planted cabbages, receiving 1 ton of soot and 6 cwt. sulphate of ammonia per acre).

SOIL : Loam. Variety : Johnson's. Manures applied : May 20, July 5. Seed sown : June 3. Lifted : November 15-16. Previous crop : Cabbages.

STANDARD ERRORS PER PLOT : Roots (washed) : 0.479 tons per acre or 4.69% ; tops : 0.406 tons per acre or 3.86% ; mean dirt tare : 0.1782.

	ROOTS (washed) Tons per acre	TOPS Tons per acre	SUGAR PER-CENTAGE	TOTAL SUGAR Cwt. per acre	PLANT NUMBER Thous. per acre
Mean	*10.21*	*10.54*	*11.86*	*24.2*	*28.3*
No manure	10.42	10.79	11.96	24.9	28.5
1 cwt. of nitrate of soda at seeding	10.01	10.47	12.00	24.0	28.3
1 cwt. of nitrate of pot. at seeding	10.02	10.40	11.68	23.4	28.1
1 cwt. of nitrate of soda at singling	10.20	10.39	12.16	24.8	28.2
1 cwt. of nitrate of pot. at singling	10.40	10.65	11.48	23.9	28.4
Standard Errors	±0.214	±0.182			

Conclusions

No significant effects in roots or tops.

Sugar Beet. J. G. Johnson, Esq., Mattersey, Doncaster, 1935
Bardney and Brigg, Sugar Factory.

4×4 Latin square. Plots : 1/40 acre.

TREATMENTS : No manure, 5 cwt. salt and 3 cwt. muriate of potash per acre alone and in combination.

BASAL MANURING : 3 cwt. sulphate of ammonia, 5 cwt. superphosphate per acre.

SOIL : Sandy on sand. Variety : Kleinwanzleben E. Manures applied : March 29. Seed sown : April 24. Lifted : November 8. Previous crop : Rye.

STANDARD ERRORS PER PLOT : Roots (washed) : 0.509 tons per acre or 8.78 % ; tops : 0.748 tons per acre or 8.61%. Mean dirt tare : 0.1512.

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	ROOTS (washed)		TOPS		SUGAR PER-CENTAGE		TOTAL SUGAR		PLANT NUMBER	
	Tons	*Increase*	Tons	*Increase*		*Increase*	Cwt.	*Increase*	Thous-ands	*Increase*
Mean ..	*5.80*		*8.68*		*15.84*		*18.4*		*24.8*	
None ..	4.55		7.17		15.38		14.0		21.9	
Salt ..	6.29	*+1.74*	9.94	*+2.77*	16.02	*+0.64*	20.2	*+6.2*	25.4	*+3.5*
Mur. pot.	5.43	*+0.88*	8.07	*+0.90*	15.86	*+0.48*	17.2	*+3.2*	24.3	*+2.4*
Both ..	6.93	*+2.38*	9.54	*+2.37*	16.09	*+0.71*	22.3	*+8.3*	27.6	*+5.7*
St. Errors	±0.254	*±0.359*	±0.374	*±0.529*						

Conclusions

Salt and muriate of potash both gave significant increases in the yields of roots and tops, the increases due to salt being significantly greater than those due to muriate of potash. The treatments also increased the sugar percentage.

Sugar Beet. J. A. Stevenson, Esq., Billinghay, 1935
Bardney and Brigg Sugar Factory
F. Wakerley, Esq., County Organiser.

5 × 5 Latin square. Plots : 1/40 acre.

TREATMENTS : No manure (A), 3 cwt. nitrate of soda (B), 3 cwt. nitrate of potash (C), 3 cwt. nitrate of soda and 2 cwt. muriate of potash (D), and 3 cwt. nitrate of potash and 0.92 cwt. muriate of potash per acre (E).

BASAL MANURING : No dung. 4 cwt. superphosphate per acre.

SOIL : Good fen, on clay. Variety : Kleinwanzleben Z. Manures applied : April 12. Seed sown : April 26. Lifted : Oct. 17. Previous crop : Wheat.

STANDARD ERRORS PER PLOT : Roots (washed) : 0.487 tons per acre or 3.60% ; tops : 0.619 tons per acre or 5.51%. Mean dirt tare : 0.1679.

	ROOTS (washed)		TOPS		SUGAR PERCENTAGE		TOTAL SUGAR		PLANT NUMBER	
	Tons	*Increase*	Tons	*Increase*		*Increase*	Cwt.	*Increase*	Thou-sands	*Increase*
Mean	*13.51*		*11.22*		*17.54*		*47.4*		*23.2*	
A ..	12.89		8.98		18.05		46.5		23.4	
B ..	13.83	*+0.94*	11.92	*+2.94*	17.25	*−0.80*	47.7	*+1.2*	23.2	*−0.2*
C ..	12.91	*+0.02*	10.95	*+1.97*	17.59	*−0.46*	45.4	*−1.1*	22.5	*−0.9*
D ..	14.14	*+1.25*	12.40	*+3.42*	17.33	*−0.72*	49.0	*+2.5*	24.0	*+0.6*
E ..	13.76	*+0.87*	11.86	*+2.88*	17.50	*−0.55*	48.2	*+1.7*	22.9	*−0.5*
St. Errors	±0.218	*±0.308*	±0.277	*±0.392*						

Conclusions

Apart from nitrate of potash applied alone, the fertilisers gave significant increases in roots and tops and significant decreases in sugar percentage, there being no significant differences between the different fertilisers. Nitrate of potash applied alone behaved anomalously, giving no increase in roots, a smaller increase in tops and a smaller decrease in sugar percentage.

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Sugar Beet. W. Arden, Esq., Newton-on-Trent, 1935
Bardney and Brigg Sugar Factory
A. McVicar, Esq, County Organiser.

5 × 5 Latin square. Plots : 1/40 acre.

TREATMENTS : No manure, 1.08 cwt. muriate of potash, 3 cwt. nitrate of soda, alone and in combination; and 3 cwt. nitrate of potash per acre.

BASAL MANURING : 3 cwt. superphosphate per acre.

SOIL : Sand. Variety : Dippe E. Manures applied : April 18. Seed sown : May 1. Lifted : December 5. Previous crop : Carrots.

STANDARD ERRORS PER PLOT : Roots (washed) : 0.708 tons per acre or 5.95% ; tops : 0.656 tons per acre or 12.4%. Mean dirt tare : 0.1372.

	ROOTS (washed)		TOPS		SUGAR PERCENTAGE		TOTAL SUGAR		PLANT NUMBER	
	Tons	*Increase*	Tons	*Increase*		*Increase*	Cwt.	*Increase*	Thous.	*Increase*
Mean	*11.89*		*5.29*		*17.27*		*41.0*		*26.6*	
None	10.70		4.00		17.42		37.3		26.6	
N/Soda	12.56	*+1.86*	6.10	*+2.10*	17.32	*−0.10*	43.5	*+6.2*	26.9	*+0.3*
Mur.pot.	10.58	*−0.12*	4.23	*+0.23*	17.46	*+0.04*	36.9	*−0.4*	25.6	*−1.0*
N/S and mur.pot.	12.72	*+2.02*	5.91	*+1.91*	16.96	*−0.46*	43.1	*+5.8*	27.0	*+0.4*
N/Pot.	12.91	*+2.21*	6.22	*+2.22*	17.18	*−0.24*	44.4	*+7.1*	26.9	*+0.3*
St. Errors	±0.317	*±0.448*	±0.293	*±0.414*						

Conclusions

Potash did not appear to have any effect. Nitrate of soda and nitrate of potash both gave significant increases in the yields of roots and tops, the increases not being significantly different.

Kale. Oxcroft, Derbyshire, 1935.
G. E. Limb, Esq., Derbyshire Education Committee.

4 randomised blocks of 6 plots each. Plots : 1/60 acre. (Outside rows discarded at harvest).

TREATMENTS : All combinations of

Sulphate of Ammonia {None, 2 cwt., 4 cwt.} × Superphosphate {None, 4 cwt.}

BASAL MANURING : $1\frac{1}{2}$ cwt. 20% potash salt per acre.

SOIL : Magnesian limestone, medium strong loam. Variety : Thousand head. Manures applied : June 3. Seed sown : June 4. Harvested : October 21-29. Previous crop : Oats, grown without manure.

STANDARD ERROR PER PLOT : 1.33 tons per acre or 11.0%.

Yields, Tons per Acre (±0·665)

Superphosphate cwt.	Sulphate of ammonia, cwt. 0	2	4	*Mean* (*±0.384*)	*Increase* (*±0.543*)
0	8.22	12.66	15.88	*12.25*	
4	8.20	11.75	16.28	*12.08*	*−0.17*
Mean (*±0.470*)	*8.21*	*12.20*	*16.08*	*12.16*	
Incr. (*±0.665*)		*+3.99*	*+3.88*		

Conclusions

There was a significant response to sulphate of ammonia, with no sign of deviation from linearity of response. There was no apparent response to superphosphate.

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Kale. Midland Agricultural College, Loughborough, 1935

4 randomised blocks of 6 plots each. Plots: 1/48.8 acre.

TREATMENTS:

$$\left\{\begin{array}{l}\text{None}\\ \text{3 cwt. nitro-chalk}\\ \text{6 cwt. nitro-chalk}\end{array}\right\} \times \left\{\begin{array}{l}\text{Unthinned}\\ \text{Thinned}\end{array}\right\}$$

BASAL MANURING: 16 tons farmyard manure, 10 cwt. basic slag (15% P_2O_5), 2 cwt. potash salt (30% K_2O).

SOIL: Light loam. Variety: Marrow stem. Manures applied: phosphate and potash in February; nitrochalk, May 2. Seed sown: April 17. Harvested: December 6-January 3. Previous crop: Wheat.

SPECIAL NOTE: Thinned plants 9 ins. to 10 ins. apart. Unthinned, chopped out to 6 ins. and left in groups of three or four plants.

STANDARD ERROR PER PLOT: 2.30 tons per acre or 6.55%.

Tons per acre (±1.15)	Nitro-chalk (cwt.) None	3	6	*Mean* (±*0.664*)	*Increase* (±*0.939*)
Unthinned ..	32.33	35.30	39.57	*35.73*	
Thinned ..	34.39	33.93	35.23	*34.52*	*−1.21*
Mean (±*0.813*)	*33.36*	*34.62*	*37.40*	*35.13*	
Incr. (±*1.15*)		*+1.26*	*+2.78*		

Conclusions

There was a significant response to nitro-chalk where the plants were not thinned. With thinning the response to nitro-chalk was small and not significant. The average effect of thinning was not itself significant.

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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.

For green weights *read* hay *in the following tables* :

1932 Report, p.129. Four Course Rotation, Rothamsted. Yields of Seeds Hay.

p.132. Six Course Rotation, Rothamsted. Yields of Clover and Forage.

p.133. Six Course Rotation, Woburn. Yields of Clover and Forage.

1934 Report, p.164. Four Course Rotation, Rothamsted. Yields of Clover Hay.

p.168. Six Course Rotation, Rothamsted. Yields of Clover Hay.

Wheat after Fallow—Hoos Field. Compass point should read " W " instead of " N " in the following Reports :

1932 Report, p.119.
1933 Report, p.104.
1934 Report, p.136.

1934 Report, p.23. Table at foot. The figures for sugar per cent. and sugar per acre should be :

	Sulphate of Ammonia.			Superphosphate.			Muriate of Potash.		
Cwt. per acre	0	2	4	0	3	6	0	1½	2½
Sugar, per cent.	17.9	17.7	17.5	17.7	17.7	17.6	17.6	17.8	17.8
Sugar, cwt. per acre	46.0	47.8	49.0	47.1	47.5	48.1	47.0	48.4	47.4

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Lawes Agricultural Trust

JANUARY—DECEMBER, 1935

The Incorporated Society for Extending the Rothamsted Experiments

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

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