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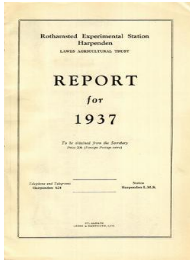
Report for 1937


Rothamsted Experimental Station
Harpenden

REPORT
for
1937

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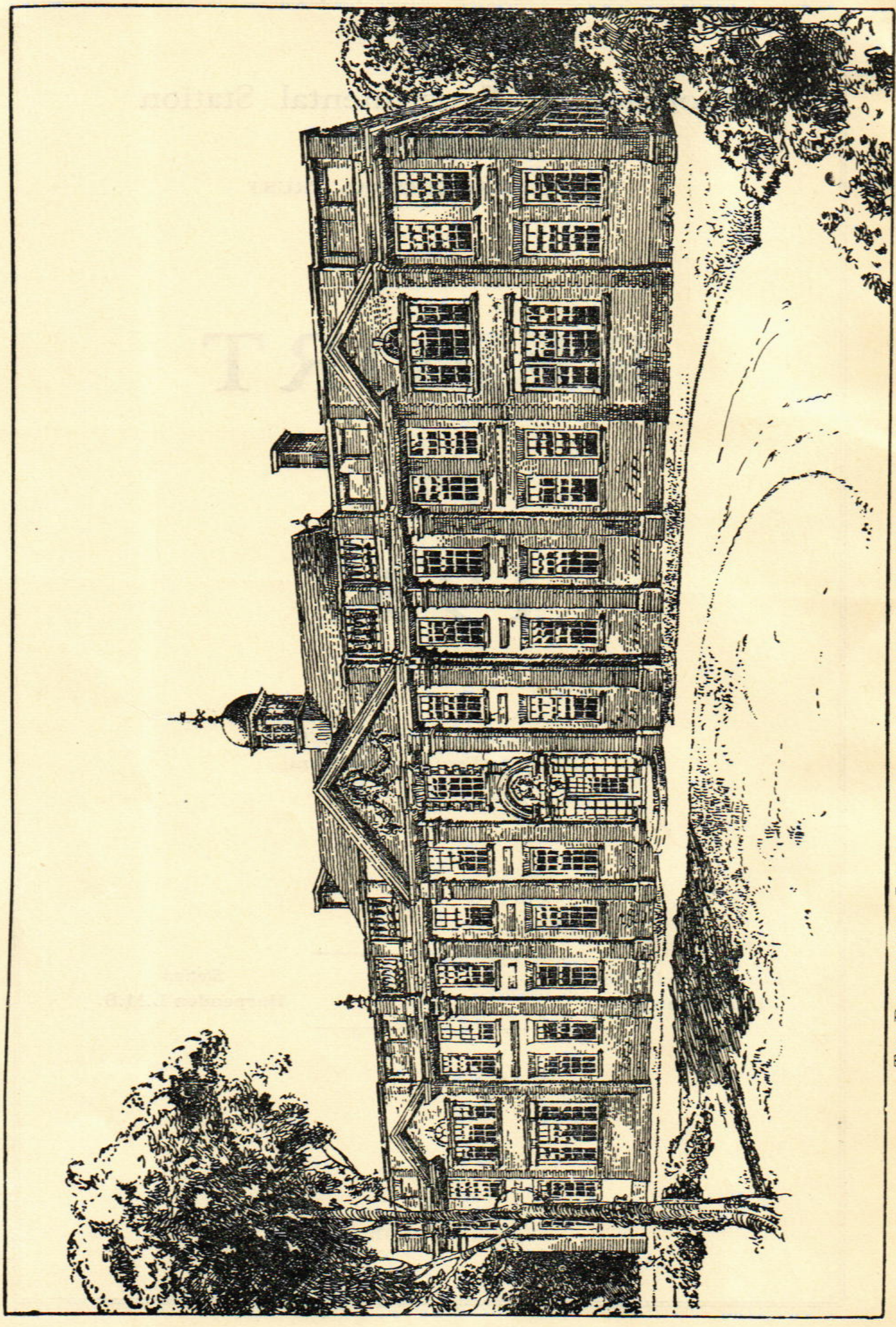

THE ROTHAMSTED LABORATORIES FOR SOIL AND PLANT NUTRITION, ERECTED 1914-1916.

REPORT
FOR
1937

CONTENTS

Experimental Station Staff

JANUARY—DECEMBER 1937

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

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Assistant Bacteriologist ..	HUGH NICOL, PH.D., F.I.C.
Post-Graduate Research Worker	CHEN HWA-KUEI, B.SC.
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Laboratory Attendant ..	MARIE PAINE

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	CONSTANCE HULL

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	G. NAGELSCHMIDT, Dr. Phil.
	J. B. HALE, PH.D.
	J. W. DEWIS, B.SC.
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	H. A. SMITH
	JOAN HELLYER
	ALICE KINGHAM
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	N. W. Barritt, M.A.
	R. Wilkinson, M.Sc.
Post - Graduate Research Worker	N. S. Bamji, M.Sc.
Laboratory Assistant ..	Stella Ward

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	T. G. Tomlinson, M.Sc.
	Annie Dixon, M.Sc., F.R.M.S.
	Jane Meiklejohn, Ph.D.
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	S. H. Harper, Ph.D., A.R.C.S., D.I.C.
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	Muriel Corke
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	H. L. Penman, M.Sc., A.Inst.P.
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	A. Arena, Eng. Ag.
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Assistant	Jessie Walker
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	R. S. Wilkinson
	R. Yates
Laboratory Attendant ..	Monica Waller

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	Peggy Hurt
	Joan Lawson
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Entomologist ..	Marion A. Watson, Ph.D.
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	E. H. Gregory
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	Prof. W. Southworth
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	G. Weston

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	A. T. Legg
	F. J. Richards, M.Sc.
Assistant	A. R. Williams

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	C. Mepham
	W. Cain
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	A. J. Smith
Tractor Driver	J. Underhill
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	G. Sygrove

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Assistant Secretary ..	Constance K. Catton
Director's Private Secretary	Annie E. Mackness
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Junior Clerks	Olive Munt
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	Betty Jackson

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Assistant Caretaker ..	F. K. Hawkins

Members of Permanent Staff who left between January 1st and December 31st, 1937, and the Appointments to which they proceeded :

G. W. Scott Blair, M.A., Ph.D.,
Head of Chemical Department,
National Institute for Research in Dairying,
Shinfield,
Reading.

C. R. Marshall, Ph.D., A.I.C.,
Bacteriologist to
Messrs. Seagar, Evans & Co.,
Distillers,
Deptford, London.

A. G. Norman, D.Sc., F.I.C.,
Professor of Soil Bacteriology,
Iowa State College,
Iowa, U.S.A.

H. L. Richardson, Ph.D., F.I.C.,
Adviser in Soils and Fertilizers to the
National Research Bureau,
Nanking, China.

G. Samuel, M.Sc.,
Mycologist to
Ministry of Agriculture Plant Pathological Laboratory,
Milton Road, Harpenden.

Temporary Workers, 1937—

In addition to those temporary workers recorded in the list of staff, the following sent officially by Governments or Universities, or who have come on their own resources, have worked at the Station for varying periods during the year 1937.

(1) From the Empire :
Australia : Dr. H. C. Forster
India : Dr. K. D. Baweja, Dr. A. Lal, Dr. M. R. Madhok, Dr. B. N. Mitra, S. Singh, R. B. Vaidyanathan.
Kenya : W. O. Sunman
New Zealand : Miss E. B. Kidson
South Africa : J. R. H. Coutts.

(2) From Foreign Countries :
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Holland : W. Stehouwer
Roumania : Dr. N. Hulpoi
Siam : R. Purnariksha
Sweden : Dr. A. Åslander

(3) From British Isles :
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Aspley Guise, Bletchley, Beds.

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Station : **Ridgmont, L.M.S.**

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

Farm Staff—

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

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Deputy Director : G. V. JACKS, M.A., B.Sc.

Scientific Assistants : A. J. LLOYD LAWRENCE, M.A.

HELEN SCHERBATOFF

Assistant Abstractors : JANET N. COMBE

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Secretary : MONA B. STAINES

Clerks : MARY ELLINGHAM, JOAN SAUNDERS

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

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

For Students and Agricultural Experts

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

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

"Soil Conditions and Plant Growth," by E. J. Russell, D.Sc., F.R.S. Seventh Edition, 1937. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 21/-.

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

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

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

"The Physical Properties of the Soil," by B. A. Keen, D.Sc., F.R.S. 1931. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 21/-.

"Problems in Soil Microbiology," by D. Ward Cutler, M.A., and Lettice M. Crump, M.Sc. 1935. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 9/-.

"Fifty Years of Field Experiments at the Woburn Experimental Station," by E. J. Russell, D.Sc., F.R.S., and J. A. Voelcker, C.I.E., M.A., Ph.D., with a Statistical Report by W. G. Cochran, M.A. (Rothamsted Statistical Department). 1936. Longmans, Green & Co., 39 Paternoster Row, London, E.C.4. 21/-.

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

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

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

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

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

"Guide to the Experimental Farm, Rothamsted."

"Catalogue of Journals and Periodicals in the Rothamsted Library." 1921. 2/6.

"A Descriptive Catalogue of Printed Books on Agriculture from 1471 to 1840, contained in the Rothamsted Library" (including Biographical notices of the authors and short descriptions of the important books). 1926. 331 pp. 22 illustrations. Cloth cover, 12/-; paper cover, 10/-. Packing and postage extra:—British Isles, 9d.; Overseas, Dominions and other countries, 1/3.

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

For use in Schools

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

For General Readers

"The Farm and the Nation," by E. J. Russell, D.Sc., F.R.S. 1933. George Allen and Unwin, Ltd., 40 Museum Street, London, W.C.1. 7/6.

"The Fertility of the Soil," by E. J. Russell, D.Sc., F.R.S. The University Press, Cambridge. 4/-.

"The Possibilities of British Agriculture," by Sir Henry Rew, K.C.B., and Sir E. J. Russell, D.Sc., F.R.S. 1923. 1/-. Obtainable from the Secretary, Rothamsted Experimental Station, Harpenden, Herts.

"Personal Reminiscences of Rothamsted Experimental Station," 1872-1922, by E. Grey, formerly Superintendent of the Experimental Fields, 5/-. Obtainable from the Secretary, Rothamsted Experimental Station, Harpenden, Herts.

"Cottage Life in a Hertfordshire Village," by E. Grey. 1935. A companion volume to "Personal Reminiscences of Rothamsted Experimental Station." Fisher, Knight & Co., St. Albans, 3/6. Obtainable from the Secretary, Rothamsted Experimental Station, Harpenden, Herts.

Other Books by Members of the Staff

"Evolution, Heredity and Variation," by D. W. Cutler, M.A., F.L.S. 1932. Christophers, 22 Berners Street, London, W.1. 4/6.

"Statistical Tables for Biological, Medical and Agricultural Research," by R. A. Fisher, M.A., Sc.D., F.R.S., and F. Yates, M.A. 1938. Oliver & Boyd, Edinburgh. 12/6. This book is designed to provide, under a single cover, all those tables normally required for statistical work in biological and agricultural research. In addition to the tables already published in *Statistical Methods for Research Workers*, and similar tables, the book includes tables of random numbers, Latin squares and other experimental arrangements, the probit and angular transformations, orthogonal polynomials, and various other tables of use to the research worker. Many of these tables are published here for the first time. The book also includes 5 figure logarithms (natural and to base 10) square roots, etc., and exact squares of three figure numbers.

Mezzotint Engravings

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

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Plans and Drawings of the old Rothamsted Laboratory, 1852

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

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

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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 1937-38, the Ministry of Agriculture has made a grant of £28,715 for the work of the Station. Lord Iveagh has generously borne the cost of a chemist and a special assistant for field experiments for studying farmyard manure, both natural and artificial; while other donors have, from time to time, generously provided funds for special apparatus and equipment. The Fertiliser Manufacturers' Association and the United Potash Company provide considerable funds for the rather expensive field work. Imperial Chemical Industries, and the Association of British Chemical Manufacturers, have provided a special assistant for the study of soil insecticides. In addition, British Sugar Corporation, British Basic Slag Companies, the Royal Agricultural Society, Dunlop Plantations, Ltd., the Institute of Brewing 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 houses, some of which are insect proof, was erected in 1935 for Plant Pathology investigations at a total cost of £2,283, towards the cost of which the Ministry of Agriculture made a grant of £1,025.

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

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

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

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

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

The activities of Rothamsted, however, are not confined to the British Isles, but are gradually spreading out to the Empire and other countries abroad. The International 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, Malaya, Nyasaland, Tanganyika, and Canada to discuss agricultural problems and possibilities of co-operation; in addition, visits are paid to the United States and to European countries, including Russia, to discuss problems and methods with experts there, and generally to improve the equipment of the Institution and widen the knowledge and experience of the staff.

More and more workers are coming from the overseas Dominions to carry on their studies at Rothamsted. Only University graduates are eligible, and most are, or are about to be, on the staffs of Government or other Agricultural Departments: men who will become leaders in the agricultural communities of their respective countries. To our great regret, lack of accommodation has compelled us to refuse some who wished to come.

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

REPORT FOR 1937

THE PROBLEMS BEFORE THE RESEARCH STATIONS

The main outlines of the problem before the agricultural research stations are clear and incontestible. Since 1919 the area of arable land in England and Wales has fallen by 3.2 million acres, while the grassland has increased only by 1.3 million acres : the total loss of agricultural land has, therefore, been 1.9 million acres. Since 1914 the loss has been even greater, amounting to 2.3 million acres. The growth of the towns is responsible for only about 20 per cent. of this loss : most of it represents simply reversion to rough grazing. The figures are shown in Table 1.

TABLE I

England and Wales : thousand acres

	1914	1919	1936	Loss or gain between 1919 and 1936
Arable land	10,998	12,309	9,120	3,189 loss
Grass land	16,115	14,439	15,743	1,304 gain
Total cultivated area . .	27,113	26,748	24,863	1,885 loss
Rough grazings	3,782	4,121	5,433	1,312 gain
Forest	1,884	1,884 (1)	2,000 (2)	116 gain
Other purposes (towns, villages, roads, etc.) . .	4,357	4,383	4,837	454 gain
Total land area	37,136	37,136	37,133	

[1] 1924 Census.
[2] 3,200 thousands for Great Britain, an increase of 200 thousands since 1924.

Simultaneously there has been a fall in the numbers of workers on the land. From 1921 to 1936 the fall has amounted to nearly a quarter of a million, all told, for England and Wales :—

	Regular men and boys thousands	Total workers, including women and casuals thousands
1921	612	869
1936	502	641
Fall	110	228

Only about 40 per cent. of our food is produced at home, the amount varies, however, for the different foods. The proportion of home production and importation of the different foods in the United Kingdom is as follows :—

https://doi.org/10.23637/ERADOC-1-69

	Percentage		
	Home-produced	Imported	
	1935	1935	1936
Butter	10	90	91
Wheat	26	74	77
Cheese	30	70	71
Sugar	30	70	52
Meat—			
Beef and Veal ..	52	48	48
Mutton and lamb ..	43	57	56
Pork and bacon ..	50	50	48
Eggs	66	34	38
Poultry (1)	76	24	25
Potatoes	96	4	6
Liquid milk	100	—	—

[1]Great Britain

It is not safe to count on a continuation of importation of the kind that we have had hitherto. Much of our imported food was produced under conditions of prairie farming and ranching which are now passing. A new farming will no doubt arise in these countries but neither quantities nor prices of the products can be foretold, and the wisest policy is undoubtedly to do as much as we can towards feeding ourselves.

For a good deal of the home production the farmer is dependent on materials such as fertilizers and feeding stuffs supplied from outside.

In face of this shrinking area of land and diminishing number of workers how is the farmer to maintain and if possible increase his output of food ? And even more important, what can be done to stop the shrinkage ?

There are various possible remedies, social, economic and technical, but the line adopted at the experimental stations is to seek means whereby the efficiency of the farmer and of the worker can be increased so that he may with the same expenditure of time and energy produce more food. Thus can higher wages be afforded for the worker and a better standard of life for the countryman. Greater efficiency turns in the end on greater knowledge of the materials and of the conditions necessary for their most successful use, and it is this knowledge that experimental stations try to obtain.

The redeeming feature of what would otherwise be an entirely depressing situation is that the value of the agricultural output is well maintained in spite of the smaller number of acres and of men : calculated on the pre-war price basis the value of the output was £141.7 millions in 1925 for 803 thousand workers, and £170.7 millions in 1936 for 641 thousand workers. These are gross values, not net values, but nevertheless they indicate an increasing efficiency of production. But these figures give no ground for complacency : there still remains the vital need for increasing still further the output and efficiency of the worker : only in this way can an economic basis be found for measures to stop the drift to the town.

The part played by Rothamsted in the organised effort to improve agriculture is the study of soil and crop production. The work necessitates a competent staff, good laboratories, experimental fields, and as the essential bridge between them, the pot culture house.

Provision for the fields was made in 1934 when the agricultura part of the Rothamsted estate was purchased by the Station : this part of the problem can now be regarded as solved.

The next step has been the improvement of the laboratories, especially the Chemical and Bacteriological laboratories which for some years past have been unsuitable for their work and very overcrowded. The Bacteriological laboratory was erected in 1906, and the subject has changed so much since that date as to necessitate a completely different design and equipment. The Chemical laboratory was built in 1913 and 1914 and here also the developments of the subject demand an entirely different design. Plans have been drawn up by Mr. Michael Tapper and new laboratories are to be erected at a cost of £30,000. Towards this the Ministry of Agriculture has made a first contribution of £14,500 and a request has already gone forward for the rounding off of the sum by the addition of another £500. The other £15,000 has to be raised by the Station.

An even more important matter, however, has been the subject of preliminary discussion by the Committee. In 1943 the Station will complete its Centenary and it is proposed to celebrate the event by putting all its buildings and equipment in thorough order, providing much needed extensions, and adding sufficient to the endowment to provide for maintenance of fabric and provision for salary augmentations or Fellowships. The total sum required will be £125,000, and the appeal for the £15,000 needed for the new laboratories will constitute the first part of the Centenary Fund Appeal. Inasmuch as the Finance Acts allow of deduction of Income Tax from subscriptions to the Fund, provided they are made in the prescribed manner and spread over at least seven years, it is not intended to wait until 1943 before raising the fund but to begin in the autumn of 1938 so as to allow the necessary spread-over for those who prefer to subscribe in this particular way.

The work of the Station has continued on substantially the same lines as in the last preceding years. The experiments with crops have been made not only at Rothamsted and at Woburn but also on a number of ordinary commercial farms typical of considerable areas of land. Similar designs are used at a series of centres and they are such that the errors of the experiment can be estimated. Thus a strict comparison can be made between the results obtained in the different places, and the fullest possible information can be extracted from the experiments.

In the last two Reports extended summaries have been given of some of the investigations. These will not be repeated here : only the new results will be given, or summaries that have not yet been presented.

GRASSLAND

Rothamsted experiments on grassland fall into three groups:

(1) the effects of fertilizers on the yield and composition of hay and on the grazing value of pasture land;

(2) the effect of management on the flora of grassland;

(3) the effects of cake feeding on the composition and nutritive value of the herbage.

The general results of the first two groups of investigations were summarised in the Report for 1936; it is not, therefore, necessary to go over the ground again in detail. It is sufficient to say that the investigations on basic slag were continued and extended.

The Rothamsted Park Grass plots, begun in 1856, show in a striking way the changes brought about by continued fertilizer treatment in the flora of grassland. The changes are determined primarily by the fertilizers supplied, but they are modified by weather conditions; they are studied by making periodical botanical analyses of the herbage of the various plots.

In this experiment a fairly uniform grass field has been changed into some 15 or 20 different floral types by varying the manurial treatment. The converse experiment was started in 1928. An arable field was divided into six parts, each of which was sown with a separate grass mixture, then the whole field was put under uniform management, and botanical analyses of the herbage were made periodically. The differences in flora rapidly diminished and by 1936 the plots were all very similar. Grasses and clovers occur in approximately the same proportions on all plots irrespective of the original mixture; rye grass has become dominant on all plots, Cocksfoot has diminished, Fescue and Timothy have almost disappeared but Rough Stalked Meadow Grass forms a definite though small part of each flora.

In another field part was sown with commercial strains of grass and part with indigenous strains. Here the differences still persist and are very noticeable in the early part of the season.

The Effects of Cake Feeding

The investigation of the effects of cake feeding on the composition and nutritive value of the herbage was commenced in 1936 under the aegis of the Royal Agricultural Society which makes an annual grant towards the cost.

Among the fields that came into our possession in 1934 was a level and fairly uniform grass field, Highfield, of about 60 acres, which had been indifferently grazed and manured for many years and had, therefore, become distinctly poor though capable of better things. This field was devoted to the experiment.

Nine plots were laid out, each of 5 acres in extent: they were fenced, water was laid on, and a weighbridge was installed in the centre so as to be easily accessible from all plots.

The plots were arranged in three blocks, each of three plots. In each year one block of three plots will be grazed by bullocks and on one of the plots cake will be fed. All liveweights will be recorded.

In the next year there will be no cake fed, but another of the three plots will receive during winter and spring artificial fertilizers containing the estimated manurial equivalents of the cake. The third of the plots will be left unmanured. All three plots will then be grazed by bullocks and sheep in the proportion of 3 sheep to 1 bullock: again all weights will be recorded. From the increases in liveweight we shall be able to compare the residual values of the manure with the values of artificials supplying their supposed equivalents. In the third year no plot will be manured, so that any subsequent effect of cake feeding or of artificials can be estimated.

The arrangement of the plots is as follows :—

Year		*Block* 1			*Block* 2			*Block* 3	
	Plot 1	2	3	4	5	6	7	8	9
1937	–	–	–	–	–	–	–	–	–
1938	–	C	–	C	–	–	–	–	–
1939	–	–	M	–	–	M	C	–	–
1940	–	–	–	C	–	–	–	M	–
1941	–	C	–	–	–	M	–	–	–
1942	–	–	M	–	–	–	C	–	–
1943	–	–	–	C	–	–	–	M	–
1944				–	–	M	–	–	–
1945				–	–	–			

C is the plot receiving cake and M the one receiving artificial manures.

The experiment will thus be in triplicate, though in each year only one plot receives cake.

In order to save time at the outset Block 2 is at first treated as Block 1: this avoids considerable delay and it gives some additional information.

The changes in herbage are measured by botanical analyses; samples being obtained from small cages fixed on the plots so as to keep off grazing animals.

The first year, 1937, was devoted to uniform grazing for estimating the irregularities of the field and also for improving the technique of the experiment. In 1938 the cake feeding began.

The rates of feeding proposed are as follows :—

Cake Year. 5 fattening cattle per 5 acres receiving

	Per cent. N	Per cent. P_2O_5	Per cent. K_2O
in Early Summer (50% flaked maize, 50% undec. cotton cake)	2.6	1.6	0.9
in Late Summer (50% flaked maize, 50% dec. ground nut cake) ..	4.5	1.0	0.9

It is proposed to increase the rate of cake-feeding steadily throughout the year but taking averages we may assume per 5 acres in early summer 5 cattle with an average of 6 lb. cake per head per day for 50 days giving a total of 1,500 lb.or 13.4 cwt. food, and in late summer 5 cattle with an average of 10 lb. per head per day for 70 days giving a total of 3,500 lb. or 31.3 cwt. food.

These totals may be expressed on an acre basis as follows :—

Cwt. for one beast on one acre

	Days	Cake	N	P_2O_5	K_2O
Early summer ..	50	2.7	0.07	0.04	0.02
Late summer ..	70	6.3	0.28	0.06	0.06
Per annum ..	120	9.0	0.35	0.10	0.08

In the following winter or spring a neighbouring plot will receive the following manures :—

	Cwt. per acre	N	P_2O_5	K_2O
½ cake N as hoof and horn meal ..	0.68	0.09	—	—
½ cake N as sulphate of ammonia	0.43	0.09	—	—
⅘ cake P_2O_5 as steamed bone flour	0.27	—	0.08	—
¾ cake K_2O as sulphate of potash..	0.12	—	—	0.06
Total fertilizer	1.50	0.18	0.08	0.06

The lengths of the grazing period will, naturally, have to vary with seasonal conditions but we shall aim at getting on a fixed amount of cake per acre per annum. In the event of seasonal changes the necessary adjustments can be made in the following year in the amounts of fertilizers added.

In the two years following the cake year the stocking will be altered from time to time according to the state of the herbage, but the proportion of one bullock to three sheep will be maintained. All animals will be weighed fortnightly. The plots will be closed from some time in November and December until the herbage is ready for grazing in May or thereabouts.

Manuring of Hay

The immediate and first year residual effects on the hay crop of 8 tons compost (mainly from grass mowings) were compared with those of artificials consisting of 2 cwt. nitrate of soda, 3 cwt. superphosphate and 1 cwt. of 30 per cent. potash salt per acre. The experiment was conducted at Lady Manners School, Bakewell, Derby, and commenced in 1932. Certain plots receive their manuring only in 1932 and alternate years, others only in 1933 and alternate years, while a third set are manured every year.

TABLE II

Meadow Hay—Immediate Effects of Artificials and Compost

	Mean yield cwt. per acre	No manure in previous year		Manured in previous year	
		Response to Artificials	Response to Compost	Response to Artificials	Response to Compost
1933	39.5	+19.2	+16.4	+21.0	+9.4
1934	43.1	+8.5	+4.5	−0.3	−2.4
1935	44.3	+18.9	+14.2	+13.8	+8.9
1936	62.8	+14.9	+14.4	+10.5	+6.0
1937	70.5	+27.2	+20.7	+19.5	+7.6

The immediate response to artificials is greater than the immediate response to compost every year. Further, as is to be expected, the responses to both manures are greater on plots without manuring in the previous year than on plots which were then manured. The average differences between the increases to artificials and the increases to compost are 3.7 cwt. per acre on plots unmanured and 7.0 cwt. per acre on plots manured. This indicates that artificials are more effective relatively to compost at higher levels of yield.

TABLE III

First Year Residual Effects of Artificials and Compost

	No manure in current year		Manured in current year	
	Response to		Response to	
	Artificials	Compost	Artificials	Compost
1933	+0.7	+2.8	−0.8	−0.9
1934	+9.8	+21.7	+8.1	+7.8
1935	+2.8	+9.7	−3.2	+5.2
1936	+7.5	+10.2	+1.4	+3.4
1937	+3.2	+13.4	−1.8	−2.3

In most years there were also good responses to a previous year's dressing of manures on plots receiving no manure in the current year. The relative effectiveness of the two manures has, however, been reversed, compost giving about 6.7 cwt. per acre more than artificials. On plots manured in the current year, the residual effects were small or negligible except in 1934, in which the residual responses to the two manures were roughly equal; at these higher levels of yield compost has apparently little residual value, a result in accordance with that indicated above.

ARABLE LAND

The Liming Programme

Some of the results of the 1936-37 experiments have an important bearing on the liming programme of the Ministry of Agriculture. In many parts of England there is a dislike of magnesian limestone and of the lime prepared from it. We have made a number of experiments in different parts of the country but so far obtained no evidence that the magnesian limestones are detrimental. When used in the quantities indicated by the ordinary lime requirement methods they give fully as good results as the corresponding high-calcium products. In some pot experiments, indeed, magnesium proved beneficial, but not in any of the field experiments. No full survey has been made but there is no present evidence of widespread magnesium deficiency in English soils.

Residual Effects of Chalk

The residual effects of chalk have been studied in three experiments, in two of which there were several dressings of chalk so as to determine the most effective amount to apply.

At Tunstall on an acid sandy soil, chalk was applied in 1932 but nothing was added afterwards. Sugar-beet was grown by Mr. A. W. Oldershaw, for the first four years, 1932-5.

https://doi.org/10.23637/ERADOC-1-69

TABLE IV

Sugar Beet : Tunstall. *Root (tons per acre)*

Chalk tons per acre (1932)	1932		1933		1934		1935	
		Increase		Increase		Increase		Increase
None	1.82		2.94		Nil		Nil	
1	12.61	+10.79	11.40	+8.46	13.37	+13.37	14.64	+14.64
2	14.30	+ 1.69	13.23	+1.83	16.36	+ 2.99	15.90	+ 1.26
3	14.27	− 0.03	13.26	+0.03	16.81	+ 0.45	15.43	− 0.47
4	14.74	+ 0.47	13.91	+0.65	17.26	+ 0.45	15.97	+ 0.54
Standard Error	± 0.432	± 0.611	± 0.437	±0.618	±0.332	±0.469	± 0.242	±0.342

The plots without chalk gave negligible yields throughout. The single dressing (1 ton chalk per acre) in 1932 raised the yield of roots to 12.6 tons per acre and continued to give good crops in subsequent years, with no indication of a decrease in effectiveness. The double dressing gave a further increase in yield each year of between 1.2 and 3 tons per acre. The 3 ton dressing proved no better than the 2 ton dressing in three years out of four. For this dressing, however, the choice of plots may have been unfortunate, since the highest dressing (4 tons) did not fail similarly but gave the best yields throughout, about half a ton per acre more roots than the 2 ton dressing.

The four levels of chalk produced no apparent differences in sugar percentage. The residual effects on the tops were similar to those on roots, except that the response fell off less sharply at the two highest dressings than with roots.

The experiment was continued with barley in 1936 and clover hay in 1937.

TABLE V

Chalk : tons per acre (1932)	Barley : Grain 1936		Clover : Hay 1937	
		Increase		Increase
None	Nil		5.0	
1	14.5	+14.5	32.3	+27.3
2	17.0	+2.5	34.9	+2.6
3	18.3	+1.3	37.4	+2.5
4	18.4	+0.1	38.8	+1.4
Standard Error	—	—	±1.04	±1.47

The residual effects persist and the results are similar to those with sugar beet, except that with both crops the 3 ton dressing has given higher yields than the 2 ton dressing.

The experiment has not yet proceeded long enough to tell how long the effects of the chalk will persist, but at least in the first five years there is little sign that the effects of the 1932 dressings are disappearing. It will also be interesting to see whether the effects of the largest dressings persist longer than those of the smaller ones.

A similar experiment has been carried out by Mr. H. W. Gardner, of the Herts. Farm Institute, at Stevenage on a gravelly loam soil with somewhat smaller dressings of chalk. The experiment started in 1933 with a crop of lucerne which failed owing to drought. Winter oats followed in 1934, but the yields were not recorded. The oats were undersown with a seeds mixture, which constitutes the 1935 crop, while mangolds were grown in 1936.

TABLE VI

Chalk : cwt. per acre (1933)	1935 Hay : cwt. per acre Yield	Increase for each dressing	1936 Mangolds roots : tons per acre Yield	Increase for each dressing
None	25.5		17.22	
35	46.0	+20.5	24.92	+7.70
70	59.2	+13.2	29.12	+4.20
140	66.0	+6.8	31.49	+2.37
210	67.3	+1.3	31.57	+0.08
Standard Error	±2.70	±3.82	±1.42	±2.01

The effects of acidity are clearly much less marked than at Tunstall, moderate crops being obtained in both years even in the absence of chalk. The successive increases per 35 cwt. of chalk were 20.5, 13.2, 3.4 and 0.6 cwt. hay in 1935 and 7.70, 4.20, 1.18 and 0.04 tons mangolds in 1936. Thus the residual response falls off steadily at the higher levels of application; in particular, the highest dressing would not have proved economically efficient.

In a second experiment by Mr. Gardner, started in 1934, the residual effects on hay of chalk, potash salt, slag and Gafsa phosphate are studied alone and in combination. The phosphatic treatments have so far had no beneficial effect, while potash salt has produced only small increases which were not significant. The responses to 75 cwt. chalk applied in 1934 are shown in Table VII.

TABLE VII

Responses to 75 cwt. chalk applied in 1934, Barnet, Herts

Hay cwt.per acre	Mean response	Potash: (applied in 1934) Absent	Present	Standard error	Mean yield
1934	+1.7	+1.6	+1.8	±0.806	16.1
1935	+5.4	+5.2	+5.6	±1.17	28.8
1936	+8.6	+4.4	+12.8	±1.55	35.7
1937	+5.9	+6.3	+5.5	±1.38	25.7

As in the other experiments there is no sign that the effects of chalk are dying away, good responses being obtained in each of the last three seasons. In 1936 the effectiveness of chalk was increased by the presence of potash, the increase to chalk being 12.8 cwt. with potash present as against 4.4 cwt. with no potash. In the other years, however, the response to chalk has not been affected by potash.

Organic Manures

The growing shortage of stable manure has seriously curtailed the supply of organic manure for the soil and alternative sources are being studied. More and more there is a tendency to divert waste products to other purposes but certain products, particularly sewage sludge and town refuse, still offer some possibilities. The manurial value of town refuse treated by a new process is being tested.

The experiments on the making of artificial farmyard manure from straw have been much facilitated and improved as a result of the erection of the new building at the farm.

Early Results with Farmyard Manure at Rothamsted

On the Classical fields farmyard manure has been compared with artificial fertilisers for a long series of years under continuous cropping conditions.

TABLE VIII

Field	Crop	Period	Average Yield: No manure	Average Yield: Farmyard manure	Average Yield: Best artificial treatment
Broadbalk ..	Wheat	1852–1925	*Plot* 3. Grain 6.7 cwt. Straw 9.8 ,,	*Plot* 2*B*. Grain 19.4 cwt. Straw 34.2 ,,	*Plot* 8. Grain 20.1 cwt Straw 39.8 ,,
Hoosfield ..	Barley	1852–1928	*Plot* 1O. Grain 6.2 cwt. Straw 7.8 ,,	*Plot* 7-2. Grain 20.7 cwt. Straw 28.1 ,,	*Plot* 4*A*. Grain 18.2 cwt. Straw 23.6 ,,
Barnfield ..	Mangolds	1876–1935	*Plot* 8*O*. Roots 3.39 tons Tops 0.98 tons	*Plot* 1*O*. Roots 17.59tons Tops 3.06tons	*Plot* 4*N*. Roots 17.79tons Tops 3.86tons

Farmyard manure used annually maintains a satisfactory level of yield, which is equalled in the case of wheat grain and mangolds roots and approached in the case of barley grain by a heavy complete annual dose of artificials.

Other classical plots showed that the cumulative effects of repeated dressings of farmyard manure were considerable and persisted for a long period after the manuring was stopped. Thus on Hoosfield the following yields were recorded in the past three seasons some 65 years since the dung on Plot 7-1 was discontinued :—

Barley, cwt. per acre

Plot		1935 Grain	1935 Straw	1936 Grain	1936 Straw	1937 Grain	1937 Straw
1-0	Unmanured since 1852	5.2	11.1	5.9	12.4	2.3	6.1
7-1	14 tons dung 1852-71 then unmanured ..	20.0	23.7	12.8	18.9	3.6	13.3
7-2	14 tons dung annually since 1852	33.9	59.3	28.1	42.2	15.2	31.7

Similar results appeared on Hoosfield when the permanent potato plots, which for 26 years (1876-1901) had received annual dressings of 14 tons of farmyard manure, were discontinued and cropped with cereals without further manure. In the last four crops for which yields were recorded the figures were :—

TABLE IX

	Plot 1		Plot 3	
	Unmanured since 1876		Dung 14 tons per acre annually for 26 years 1876-1901, afterwards unmanured	
	Grain	Straw	Grain	Straw
	bush.	cwt.	bush.	cwt.
1918 Barley	8.4	4.0	16.2	8.6
1919 Barley	4.7	3.2	11.5	6.4
1921 Wheat	10.5	9.1	24.3	24.6
1922 Barley	13.0	7.4	21.6	11.3

The manner of storage of farmyard manure was studied in field experiments in 1915-16. The results showed the increase in crop producing power caused by keeping the dung heaps compact, and in particular by providing them with some shelter. *

* E. J. Russell and E. H. Richards, J. A. S. 1917, Vol. 8. pp. 495-563, and J. R. A. S. E. 1916, Vol. 77, pp. 1-36.

Although dung is so widely used, its effects have seldom been measured in replicated experiments owing to the difficulty of applying this bulky material to scattered small plots.

Modern Replicated Experiments on Farmyard Manure

The material available consists of eleven experiments each on sugar beet and potatoes, four on beans (summarised on p. 49), five on mangolds (summarised on p. 43), two each on swedes and kale and one on wheat. The residual effects of the manure on the succeeding crop have also been studied in several experiments.

Direct effects

TABLE X

Direct Effects of Farmyard Manure

Year	Centre	Mean yield	Increase for dung	Quantity of dung tons/acre
	Potatoes tons per acre			
1915	Rothamsted	6.71	+3.19	10
1916	Rothamsted	3.19	+1.12	20
1920	Rothamsted	9.21	+1.98	15
1932	Rothamsted	11.54	+1.10	15
1934	Rothamsted	9.95	+2.23	20
1935	Rothamsted	5.24	+2.36	15
1936	Rothamsted	5.21	+2.18	15
1937	Rothamsted	6.16	+2.46	15
1934	Wimblington	7.81	+5.00	8
1935	Wimblington	7.14	+2.47	8½
1936	Wimblington	8.25	+1.18	6½
	Sugar Beet Roots (tons per acre)			
1933	Rothamsted	6.46	+2.34	20
1934	Rothamsted	14.03	+1.26	10
1935	Rothamsted	11.57	+1.23	10
1936	Rothamsted	14.84	+1.68	10
1937	Rothamsted	14.14	+1.04	10
1937	Woburn	16.06	+0.74	10
1936	Gainsborough	12.76	+0.08	10
1936	Wragby	12.21	+0.74	10
1937	Wragby	13.45	+0.74	10
1937	Market Rasen	10.63	+0.11	10
	Mangolds Roots (tons per acre)			
1936	Rothamsted	25.50	+4.20	10
1937	Rothamsted	21.40	+2.04	10
1932	Oakerthorpe	31.20	+8.13	15
1933	Oakerthorpe	20.58	+4.21	15
1934	Oakerthorpe	19.56	+9.75	15
	Beans Grain (cwt. per acre)			
1934	Rothamsted	18.7	+1.9	10
1935	Rothamsted	21.0	+5.6	10
1936	Rothamsted	16.8	−0.1	10
1937	Rothamsted	29.0	+2.0	10
	Swedes Roots (tons per acre)			
1922	Rothamsted	29.74	+3.71	10
1923	Rothamsted	15.0	+1.1	10
	Kale (tons per acre)			
1932	Woburn	20.99	+4.44	15
1936	Woburn	13.11	+2.42	10
	Wheat Grain (bushels per acre)			
1916	Rothamsted	34.8	+3.1	10

At Rothamsted the responses in potatoes varied from 1.1 to 3.2 tons per acre, the average response to a dressing of 15 tons being 2.1 tons per acre. At Wimblington, on a light fenland soil, dressings of about 8 tons proved very effective.

A dressing of 10 tons increased the yields of sugar beet roots by 1.3 tons per acre in the Rothamsted experiments ; elsewhere the responses in roots were smaller. In most experiments dung produced a small decrease in sugar percentage.

The direct effect of 10 tons of farmyard manure is usually about equivalent to that of 2 cwt. of sulphate of ammonia. Calculated on a nitrogen basis one part of ammoniacal nitrogen is about equal to 3 parts of farmyard manure in the year of application.

In order to study the rate of exhaustion of the effects of normal dressings of dung in rotation practice an experiment on residual values was laid down in Little Hoosfield in 1904 and continued till 1926. The results showed that the dung made by cattle having a good cake ration was considerably more effective in its first year than dung made by animals on a store ration, but in the subsequent three seasons the effects of the two types of manure were very similar. The residual effects of dung of any kind were much more pronounced than those of commercial organic manures such as shoddy, guano and rape cake ; but in the fourth season after application the residues of dung only increased production some 20 per cent. above the level of the continuously unmanured control plot. The design of the Little Hoos experiment was improved in the present Four-Course Rotation experiment commenced in Hoosfield in 1930. The results of the first three years of the complete cycle were summarised in the Station Report for 1936, p. 53. Dung, Adco compost, and straw with supplementary artificials are compared in direct effects and in residual action over a 5 year period. The three forms of straw manure behave in a similar manner and their residual effects are apparent at least three years after application. As the experiment proceeds the measurement of manurial effects will gain in precision.

Methods of applying farmyard manure

In the Rothamsted potato experiments in 1932 and 1934, dung ploughed in in autumn was compared with dung ploughed in shortly before planting in spring. In the 1934 experiment there was no appreciable difference between the effects of the two times of application, while in 1932 the spring application gave an extra increase of about one ton per acre, which was, however, not significant

In the later Rothamsted potato experiments dung ploughed in during December or January was compared with dung applied in the bouts.

TABLE XI

Potatoes : tons per acre

Farmyard Manure (15 *tons per acre*)

	No dung	Ploughed in	In the bouts	Mean response	Advantage for application in bouts
1935	5.24	7.15	8.06	+2.36	+0.91
1936	5.21	6.45	8.33	+2.18	+1.88
1937	6.16	7.64	9.60	+2.46	+1.96

Application in the bouts proved definitely superior each year, giving an increase of between 1 and 2 tons per acre over the earlier application.

In the 1936 and 1937 experiments the effect of adding 2 tons of chaffed straw to the dung was also tested. With the earlier application of dung the straw was ploughed in, while with the later application the straw was mixed with the dung and stored until bouting. In both years the addition of straw produced small but not significant decreases in yield. In 1936, however, straw increased the yields on plots which also received sulphate of ammonia (applied in the bouts).

The addition of straw (1½ tons) to dung is also included in the new Woburn green manuring experiment. On plots receiving dung and 2 cwt. sulphate of ammonia, straw decreased the yield of kale by 1.0 tons per acre, while on plots receiving dung and 4 cwt. sulphate of ammonia the decrease was only 0.1 tons per acre. The difference between these figures is not significant, but it is in the same direction as in the 1936 potato experiment. In 1937 the kale crop was a very poor one and straw had no appreciable effect.

Only one experiment is available on the method of applying dung to sugar beet. At Rothamsted in 1931 dung was applied and spread three weeks before ploughing under or immediately before ploughing. The later application gave a significant increase of 0.7 tons roots over the earlier application.

TABLE XII

Responses to Artificials

Potatoes (tons per acre)

Responses to Sulphate of Ammonia

		Amount of sulphate of ammonia	Dung Absent	Dung Present	Difference Pres. minus Abs.	S.E. of difference
1932	Rothamsted ..	0.4 cwt. N	+1.85	+2.34	+0.49	±0.471
		0.8 cwt. N	+3.17	+3.22	+0.05	±0.471
1934	Rothamsted ..	0.4 cwt. N	+1.35	+1.59	+0.24	±0.476
		0.8 cwt. N	+1.65	+1.88	+0.23	±0.476
1935	Rothamsted ..	0.8 cwt. N	+1.03	+1.89	+0.86	±0.329
1936	Rothamsted ..	0.4 cwt. N	+1.52	+0.99	−0.53	±0.612
1937	Rothamsted ..	0.4 cwt. N	+1.85	+1.90	+0.05	±0.366
		0.8 cwt. N	+2.87	+3.46	+0.59	±0.366
1934	Wimblington	0.45 cwt. N	+0.29	+0.83	+0.54	±0.354
1935	Wimblington	0.5 cwt. N	+0.65	+1.26	+0.61	±0.404
1936	Wimblington	0.5 cwt. N	−0.01	+0.88	+0.89	±0.891

Responses to Sulphate of Potash

		Amount of sulphate of potash	Dung Absent	Dung Present	Difference Pres. minus Abs.	S.E. of difference
1932	Rothamsted ..	0.8 cwt. K_2O	−0.15	+0.16	+0.31	±0.471
		1.6 cwt. K_2O	+0.15	−0.10	−0.25	±0.471
1937	Rothamsted ..	1.6 cwt. K_2O	+0.73	+0.32	−0.41	±0.423
1934	Wimblington	1.12cwt. K_2O	+4.93	+2.68	−2.25	±0.354
1935	Wimblington	1.25cwt. K_2O	+2.43	−0.03	−2.46	±0.404
1936	Wimblington	1.25cwt. K_2O	+0.93	−0.03	−0.96	±0.891

Responses to Superphosphate

		Amount of superphosphate	Dung Absent	Dung Present	Difference Pres. minus Abs.	S.E. of difference
1937	Rothamsted ..	0.8 cwt. P_2O_5	+1.52	+0.85	−0.67	±0.423
1935	Wimblington	1.0 cwt. P_2O_5	+0.49	+0.45	−0.04	±0.404
1936	Wimblington	1.0 cwt. P_2O_5	+0.03	−0.80	−0.83	±0.891

For mean yields see Table X.

Effects of dung on the responses to artificials

The question whether artificials may be profitably applied on land which is also being dunged has been studied in several experiments, see Table XII on previous page. These show the responses to sulphate of ammonia and minerals in the absence and in the presence of dung.

With potatoes the responses to sulphate of ammonia were increased in presence of dung in seven out of eight experiments, the increase being significant at Rothamsted in 1935. These increases are presumably due to the minerals contained in the dung, since sulphate of ammonia produced no increase when applied without dung or minerals.

The responses to sulphate of potash were decreased by the addition of dung in four experiments out of five, the decrease being significant at Wimblington in 1934 and 1935. In the remaining experiment, potash had no appreciable effect.

The response to superphosphate was decreased in presence of dung at Rothamsted in 1937, though not significantly. At Wimblington in 1935, the response was unaltered, while in the remaining experiment the effects of superphosphate were not significant.

TABLE XIII

Responses to Artificials

Sugar Beet Roots (tons per acre)

Responses to Sulphate of Ammonia (0.6 cwt. N)

		Dung		Difference
		Absent	Present	Pres. minus Abs.
1933	Rothamsted ..	+0.15	+0.05	−0.10[1]
1934	Rothamsted ..	+1.38	+1.83	+0.45[2]
1937	Wragby ..	+1.89	+0.68	−1.21
1937	Market Rasen	+3.00	+2.28	−0.72

Responses to Muriate of Potash (1.0 cwt. K_2O)

1936	Rothamsted ..	−0.39	−0.25	+0.14
1937	Rothamsted ..	+0.74	+0.12	−0.62
1937	Woburn ..	+1.48	+0.74	−0.74

Responses to 5 cwt. Superphosphate + 3 cwt. 30% Potash Salt

1936	Gainsborough	+0.78	−0.23	−1.01
1936	Wragby ..	+0.98	+0.57	−0.41
1937	Wragby ..	+1.31	+1.30	−0.01
1937	Market Rasen	+2.32	+0.68	−1.64

S.E. of differences (1) ±0.674. (2) ±0.636.

With sugar beet roots the responses to sulphate of ammonia were not significantly affected by the addition of dung in any of the three experiments in which sulphate of ammonia produced a clear response in roots. The responses to muriate of potash were somewhat decreased by dung in two experiments; in the third, potash produced small but not significant depressions in yield both in

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presence and absence of dung. In the further experiments containing minerals (superphosphate and potash salt), the responses to minerals were slightly decreased by the addition of dung.

TABLE XIV

Kale (tons per acre)

	Woburn 1932 Sulphate of ammonia : cwt. N				Woburn 1936 Sulphate of ammonia	
	None	0.2	0.4	0.8	0.4 cwt. N	0.8 cwt. N
No dung	13.29	17.76	19.67	24.36	10.14	13.67
Dung	19.19	21.24	23.67	28.74	13.14	15.49
Standard errors	±0.713				±0.357	

With kale, the responses to sulphate of ammonia were smaller in presence of dung in both experiments, though not significantly so.

TABLE XV

Residual effects of Dung on the Succeeding crop (cwt. per acre)

Dung applied to		Amount of dung	Succeeding crop	Mean yield	Increase for dung
		tons			
Potatoes	1916	10	Wheat grain	11.9	+2.4
Potatoes	1920	15	Wheat grain	17.8	+3.6
Potatoes	1936	15	Spring oats grain	20.2	+2.7
Kale	1932	15	Barley total produce	95.1	+12.2
Kale	1936	15	Barley grain	12.0	+2.2
Barley	1921	14	Clover 1921 green weight	9.2	+6.7
			Clover 1922 hay	45.5	+8.2
			Clover 1923 hay	13.0	+2.3

The residual effects are striking. Dung applied to potatoes or kale increased the succeeding cereal crops by over 2 cwt. grain per acre in every case. In an experiment in which dung was applied to barley, clover sown under the barley continued to benefit from the dung for at least three seasons, the green weights being doubled by the dung in the first season.

POULTRY MANURE

The consignments of dried poultry manure for the 1933-36 experiments were obtained from Suffolk, but for the 1937 experiments the supply was from Hampshire : the percentages of nitrogen, phosphoric acid and potash were very similar :—

		Percentage in dried manure Nitrogen	P_2O_5	K_2O	Ash	Dry matter
1936	Suffolk	3.90	3.53	1.70	35.3	88.7
1937	Hampshire	3.75	3.43	1.76	22.2	85.1

In the first three years in which the manures were applied the poultry manure was distinctly inferior to the sulphate of ammonia. The direct effect of poultry manure, based on 29 experiments, only amounted to 64 per cent. of the direct effect of sulphate of ammonia.

In 1936 the figure was 71 per cent. as the mean of 14 experiments; 8 cwt. dried poultry manure has thus about the same value as 1 cwt. sulphate of ammonia.

The percentage increases in yield over the plots without nitrogen in 1937 are shown in Table XVI.

TABLE XVI

Comparison of Direct Effects

Crop	Percentage Increase over no Nitrogen		
	Sulphate of ammonia	Poultry manure	Difference poultry manure as against sulphate of ammonia
Potatoes	+58	+36	−22
Runner beans	+11	+7	−4
Kale	+76	+29	−47
Kale	+81	+27	−54
Early potatoes	+47	+75	+28
Mean	+55	+35	−20
Mean of 14 First Year experiments 1936 ..	+35	+25	−10
Mean of 29 First Year experiments, 1933-35 ..	+25	+16	−9

The residual effects of poultry manure were small and not statistically significant, but their existence could be inferred from the fact that the marked superiority of sulphate of ammonia over poultry manure in the year of application was reduced and in several experiments reversed when the dressings were repeated year after year.

In three out of seven cumulative experiments in 1937, the advantage is with poultry manure, whereas in the first year effects only one out of five experiments went in this direction. Nevertheless poultry manure has not done so well in the cumulative experiments of 1937 as in those of 1936, when 6 out of 7 trials showed an advantage of poultry manure over sulphate of ammonia. This result may be due in part to the excessive leaching that the land suffered during the winter of 1936-7.

The 1937 results are shown in Table XVII.

TABLE XVII

Cumulative Effects

Crop	Percentage Increase over no Nitrogen		
	Sulphate of ammonia	Poultry manure	Difference poultry manure as against sulphate of ammonia
Potatoes	+18	+9	−9
Cabbages	+23	+55	+32
Swedes, tops ..	+19	+8	−11
Potatoes	+128	+65	−63
Potatoes	+23	+37	+14
Potatoes	+36	+27	−9
Cabbages	+13	+23	+10
Mean	+37	+32	−5

Reviewing the whole of the experiments it appears that poultry manure is not uniformly better than sulphate of ammonia in the cumulative series, but it approaches sulphate of ammonia closer than in the series testing first year effects. Kale appears to be a particularly unsuitable crop for poultry manure, while the only two cabbage crops grown in 1937 showed a significant superiority of poultry manure over sulphate of ammonia.

ARABLE CROPS

Sugar Beet

Each year since 1933 the Rothamsted staff has co-operated with what has now become the Committee on Research and Education of the Sugar Commission in carrying out experiments on the manuring and cultivation of sugar beet at Rothamsted, Woburn and on a number of representative sugar beet growers' farms.

During the first three years 1933, 1934 and 1935, the responses to fertilizers were comparatively small. The summers were hot and dry, and apparently provided little opportunity for the phosphate and potash to exert their full effects. Nitrogen was the only fertilizer to justify itself in the average in these years, and the single dose of potash came next in order of effectiveness. In 1936, however, there were good responses to all nutrients and especially to phosphate; the results provided us with our first favourable opportunity for relating field responses to chemical analysis of the soils. In 1937 the responses to nitrogen and phosphate were less than in 1936, but the results from potash were the best so far recorded.

The mean increase to the three nutrients in terms of sugar per acre are shown in Table XVIII.

TABLE XVIII

Mean Responses to Nutrients in Single and Double Dressings. 1933-1937
Sugar (cwt. per acre)

Year	No. of expts.	Mean yield of roots tons p. a.	Mean yield of sugar	Sulphate of ammonia 2 cwt.	Sulphate of ammonia 4 cwt.	Superphosphate 3 cwt.	Superphosphate 6 cwt.	Muriate of potash 1¼ cwt.	Muriate of potash 2½ cwt.
1933	13	11.5	37.5	+0.4	—	+0.3	—	+0.8	—
1934	15	13.5	47.6	+1.8	+3.0	+0.4	+1.0	+1.4	+0.4
1935	23	9.5	32.4	+1.8	+2.7	+0.1	+0.4	+0.8	+0.9
1936	26	10.4	36.6	+5.5	+7.7	+1.9	+3.0	+1.2	+1.9
1937	30	11.6	40.3	+3.8	+5.2	+1.5	+1.9	+1.5	+2.8

The quantity of sugar per acre required at January 1938 prices to pay for the expenditure on fertilizers is as follows:—

cwt.		*Cwt. per acre*
2	Sulphate of ammonia ..	1.4
4	,, ,, ..	2.7
3	Superphosphate ..	1.1
6	,, ..	2.1
1¼	Muriate of potash ..	1.0
2½	,, ,, ..	1.9

So far as the experiments have at present gone the fertilizer results may be summarised as follows:—

(1) Nitrogen is almost always profitable on the average to the extent of 4 cwt. sulphate of ammonia per acre except on rich silts and fens.

TABLE XIX

Effect of Nitrogenous Fertilizers on Different Soils
Increases (+) or Decreases (−) in Sugar (cwt. per acre)

Year	Sulphate of ammonia	Coarse sands	Fine sands	Light loams	Heavy loams	Clay loams	Fens
	cwt.						
1936	2	+8.3	+4.4	+4.0	+4.9	+7.0	+3.1
	4	+11.6	+5.9	+5.6	+9.2	+9.9	+0.8
1937	2	+6.1	+3.0	+2.9	+3.4	+4.7	+0.6
	4	+7.1	+4.3	+5.4	+4.5	+6.6	−2.6

It almost invariably reduces the sugar content but this loss is more than compensated by increased yield.

TABLE XX

Effect of Sulphate of Ammonia on Sugar Content

	Mean sugar percentage	Effect of sulphate of ammonia	
		2 cwt.	4 cwt.
1933 ..	16.2	−0.3	—
1934 ..	17.7	−0.2	−0.4
1935 ..	16.9	−0.2	−0.6
1936 ..	17.6	−0.1	−0.2
1937 ..	17.3	−0.1	−0.3

The effectiveness of nitrogen on the yield of sugar per acre (Table XVIII) falls off as the dressing increases from 2 cwt. sulphate of ammonia per acre to 4 cwt. On the tops, however, the effect of nitrogen is so marked that there is no sign of falling off even when 4 cwt. sulphate of ammonia is given.

TABLE XXI

Effect of Increasing Dressings of Sulphate of Ammonia on Tops (tons per acre).
Increase due to Sulphate of Ammonia

	No. of expts.	Mean yield	2 cwt.	4 cwt.
1934 ..	11	10.9	+1.2	+2.8
1935 ..	20	8.1	+1.3	+2.6
1936 ..	18	8.4	+1.8	+3.4
1937 ..	24	9.4	+1.5	+3.0

(2) Phosphate varies in its effect from centre to centre and from season to season. Table XXII shows that the smaller dose of 3 cwt. superphosphate per acre was profitable on the average of all centres in 1936 and 1937, while the double dose was profitable over all centres in 1936 only. The sugar content is practically unaffected by phosphate, but the rate of growth of the young plant seems to be benefited in many cases. Up to the present basic slag has been no better than superphosphate even on acid soils, rather the reverse. The

effect of phosphate on tops is in the same direction as on roots but somewhat smaller.

TABLE XXII

Effect of Phosphatic Fertilizers on Different Soils
Increases (+) or Decreases (—) in Sugar (cwt. per acre)

Year	Superphosphate	Coarse sands	Fine sands	Light loams	Heavy loams	Clay loams	Fens
	cwt.						
1936	3	+2.3	+1.3	+3.0	+0.6	+2.5	+1.2
	6	+4.2	+2.7	+3.7	+1.2	+4.3	+0.2
1937	3	+1.2	+0.7	+2.6	+0.5	+0.5	+2.2
	6	+1.5	+1.4	+2.9	+2.3	+1.0	+1.0

(3) Potash had generally worked well on the lighter soils and on the fens : it had much less effect on the heavy loams and on the clays.

TABLE XXIII

Effect of Potassic Fertilizers on Different Soils
Increases (+) and Decreases (—) in Sugar (cwt. per acre)

Year	Muriate of potash	Coarse sands	Fine sands	Light loams	Heavy loams	Clay loams	Fens
	cwt.						
1936	1¼	+1.8	+2.6	+0.3	+0.2	0.0	+2.1
	2½	+3.8	+4.4	+1.5	−1.2	−1.4	+4.2
1937	1¼	+2.6	+1.7	+1.4	+1.8	+0.6	+1.0
	2½	+4.0	+3.4	+2.4	+0.7	+1.1	+3.2

It almost always improves the sugar content.

TABLE XXIV

Effect of Muriate of Potash on Sugar Content
Increase (+) or Decrease (—) Per cent.

	Mean sugar percentage	Muriate of potash cwt. 1¼	2½
1933 ..	16.2	+0.2	—
1934 ..	17.7	+0.2	+0.2
1935 ..	16.9	+0.2	+0.2
1936 ..	17.6	+0.1	+0.2
1937 ..	17.3	+0.1	+0.3

Potash also has the valuable property of bringing out the best value of nitrogenous manures ; the joint action of nitrogen and potash has usually been greater than the sum of their separate effects.

TABLE XXV

Effect of Potash on the Action of Nitrogenous Manure. Sugar (cwt. per acre)
Increase due to 4 cwt. Sulphate of Ammonia

	No potash present	2½ cwt. muriate of potash present
1934	+2.0	+4.1
1935	+1.7	+3.7
1936	+6.9	+8.5
1937	+4.8	+6.5

Potash also increases the tops, but to a less extent than the roots.

The effect of fertilizers on plant number per acre is somewhat variable but tends to be favourable: the magnitude of the effects, however, is usually small.

TABLE XXVI

Effect of Fertilizers on Plant Numbers

Increase, thousands per acre due to

Year	Mean thousands per acre	Sulphate of ammonia		Superphosphate		Muriate of potash	
		2 cwt.	4 cwt.	3 cwt.	6 cwt.	1¼ cwt.	2½ cwt.
1933	22.8	+0.3	—	+0.5	—	+0.4	—
1934	27.4	+0.2	+0.4	0.0	+0.1	+0.2	+0.2
1935	29.7	+0.4	+0.3	+0.2	0.0	+0.2	+0.1
1936	25.9	+0.2	0.0	+0.4	+0.6	+0.1	+0.3
1937	28.3	+0.3	+0.3	+0.5	+0.3	+0.4	+0.7

No clear relationships have yet been found between fertilizers and the purity of the juice.

Methods of applying mineral manures to sugar beet. Experiments to compare several methods of applying mineral manures to sugar beet were carried out at five centres in 1936 and six centres in 1937. The treatments consisted of no minerals, minerals ploughed in or broadcast during December or January, and minerals broadcast in spring, shortly before sowing. Though minerals increased the yields at ten of the eleven centres, none of the three methods of application proved consistently superior to the others. The only significant differences occurred in both years on a sandy loam soil at East Kirkby, where winter applications proved superior to the spring application.

TABLE XXVII

Effect of Time and Method of Applying Minerals

Sugar. Cwt. per acre

Centre	None	Minerals Pl/w	Minerals Br/w	Minerals Br/s	Mean of minerals	Pl/w minus Br/w	Standard error	Winter minus spring	Standard error
1936 Experiments							±		±
Wragby	42.2	46.0	46.8	46.0	46.3	−0.8	0.993	+0.4	0.860
Scotter	45.0	46.3	45.9	46.2	46.1	+0.4	0.970	−0.1	0.840
Habrough ..	59.2	59.7	58.1	57.8	58.5	+1.6	2.02	+1.1	1.75
East Kirkby ..	25.4	34.4	37.4	33.7	35.2	−3.0*	1.25	+2.2*	1.08
Harper Adams ..	62.4	66.8	66.8(1)	68.6	67.4	0.0	1.37	−1.8	1.19
1937 Experiments									
Rothamsted ..	42.8	43.7	47.4	48.1	46.4	−3.7	2.33	−2.5	2.02
Woburn	53.3	54.8	56.6	57.0	56.1	−1.8	1.65	−1.3	1.43
Wragby	44.6	50.3	49.6	49.0	49.6	+0.7	1.56	+1.0	1.35
Market Rasen ..	34.3	39.4	40.8	40.9	40.4	−1.4	1.48	−0.8	1.29
East Kirkby ..	38.7	48.7	48.8	45.0	47.5	−0.1	1.73	+3.8*	1.49
Blyborough ..	49.7	54.0	53.6	51.3	53.0	+0.4	2.06	+2.5	1.79

(1) Minerals harrowed in. * Significant difference.

Pl/w = Winter ploughed. Br/w = Winter broadcast. Br/s = Spring broadcast.

Minerals at all centres: superphosphate plus muriate of potash, except Rothamsted and Woburn: salt plus muriate of potash.

The Fertilizer Effects of Salt

1. *Sugar beet.* Experiments on the manurial value of salt have been confined mainly to sugar beet : two, however, were made on celery and two on mangolds.

The results of 16 experiments in which salt was compared with muriate of potash are shown in Table XXVIII. In 10 of these experiments the comparison was made on an equivalent chloride basis, with dressings of salt varying from 1.0 to 2.5 cwt. per acre and of potash from 1.2 to 3.0 cwt. per acre. Salt proved consistently the more effective, the average response to 1 cwt. being 0.47 tons roots, while the corresponding dressing of 1.2 cwt. muriate of potash gave an average increase of 0.33 tons roots. Apart from this difference, the effects of the two minerals were generally similar ; where one gave a good response, the other did likewise.

TABLE XXVIII

Sugar Beet : Roots

Year	Place	Amount cwt. per acre: Salt	Amount cwt. per acre: Muriate of potash	Mean yield roots (tons)	Increase to salt	Increase to potash	Increase to combined dressing	S.E of increase
1929	Rothamsted	1.4	1.7	7.42	+0.28	+0.12	+0.26	±0.112
	Colchester	3.9	1.6	6.73	+0.95	+0.57	—	±0.362
1930	Rothamsted	1.4	1.7	7.44	+0.27	+0.23	+0.07	±0.182
	Woburn	1.0	1.2	9.27	+0.52	+0.17	—	±0.396
	Wye	1.6	2.0	13.04	+0.44	+0.71	+0.69	±0.194
	Northampton	1.8	2.0	11.31	+1.77	+1.68	+1.46	±0.683
1931	Wye	1.1	1.6	11.11	+0.13	−0.36	−0.06	±0.239
1932	Colchester	1.5	2.0	5.63	+0.53	+0.22	+0.58	—
1934	Rothamsted	1.3	1.5	15.36	+0.39	+0.74	+0.88	±0.379
	Lincoln	5.0	2.0	10.38	+0.11	−0.18	+0.89	±1.12
	Doncaster	2.5	3.0	8.21	+1.51	+0.95	—	±0.279
	Wood Norton	1.5	1.8	14.55	+1.19	+0.67	+1.62	±0.740
1935	Mattersey	5	3	5.80	+1.74	+0.88	+2.38	±0.359
1936	Rothamsted	5	1	14.84	+1.04	−0.18	+0.58	—
1937	Rothamsted	5	1	14.08	+1.46	+0.21	+1.38	—
	Woburn	5	1	16.06	+0.63	+1.11	+0.65	—

In five of the remaining six experiments in the table, the dressing of salt was 5 cwt. per acre, while that of muriate of potash varied from 1 to 3 cwt. To compare equivalent dressings of the minerals from these experiments might be unfavourable to salt, since large dressings of a fertilizer frequently prove less effective per unit of the fertilizer than small dressings. At Lincoln (1934) neither dressing was effective. Both minerals produced significant increases in roots at Mattersey (1935), salt being superior to potash even on an equivalent chloride basis. At Rothamsted (1936 and 1937) salt gave good responses, although muriate of potash had little or no effect. At Woburn (1937), on the other hand, 1 cwt. muriate of potash per acre increased the roots by 1.11 tons, while 5 cwt. salt produced an increase of only 0.63 tons. The dressings in the only remaining experiment (Colchester 1929) were 3.9 cwt. salt and 1.6 cwt. muriate of potash. Salt gave the larger response.

The combined dressing was not in general so effective as the individual dressings. Where there was a clear response to minerals, the sum of the responses to the individual dressings of salt and muriate of potash was always greater than the response to the combined dressing.

The experiments do not provide sufficient material to determine whether salt is chiefly a light land fertilizer, because all the experiments except those at Rothamsted were on light or sandy soils. Salt, however, increased yields in all five experiments at Rothamsted. The contrast between the 1937 results at Rothamsted and at Woburn is striking, salt giving good increases at Rothamsted where muriate of potash had little effect, whereas with the same dressings at Woburn muriate of potash was the more effective.

Both salt and muriate of potash slightly, but fairly consistently, increased the sugar percentage. In the 10 experiments with small applications the equivalent dressings of the two minerals produced exactly the same average increase in sugar percentage, 0.21 for 1 cwt. salt or 1.2 cwt. muriate of potash. In the remaining experiments both minerals produced substantial increases in sugar percentage at Lincoln and Mattersey, but at other centres their effects were small.

The factory series of sugar beet experiments have shown that the addition of muriate of potash tends to increase the response to sulphate of ammonia. Little information has yet been obtained on the behaviour of salt in this respect. Three experiments contained salt and muriate of potash alone and in combination with a nitrogenous fertilizer. In no case, however, was the response to nitrogen appreciably affected by the presence of either salt or muriate of potash.

2. *Celery*. Experiments on celery were carried out at Mepal (Isle of Ely) in 1935 and 1936. In the first year there were significant increases in total produce of 0.43 tons per acre to 5 cwt. salt and of 0.89 tons per acre to 3 cwt. muriate of potash. Both minerals also produced a significant increase in the size of heads. The latter result is important commercially, the heads being graded by size when packed for market.

The effect of salt was strikingly different in 1936. Salt was applied in dry weather, six days before planting. No rain fell for some time afterwards. The salt decreased plant numbers by nearly 30 per cent. and yields of total produce by 16 per cent. Superphosphate visibly mitigated the salt damage, and to some extent this effect is also reflected in the yields of total produce. Under the same conditions muriate of potash produced a small but not significant increase in total yield and a significant increase in size of heads.

3. *Mangolds*. The effects of salt on mangolds are summarised on p. 43.

MANGOLDS

The classical experiments on Barnfield are made in the somewhat exceptional conditions of continuous growth of mangolds on the

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same land. Experiments under more normal conditions were made on Great Harpenden field in 1936 and on Great Knott field in 1937 in which two levels of each of five different fertilizers were tested in all combinations. The design of the experiment was such that each experiment involved only 32 plots, thus making efficient use of the land available.

The results in the two years agreed well, and accorded with those obtained on the Barnfield experiments.

The mean yields and average responses in roots are shown in Table XXIX

TABLE XXIX

	Mangolds roots : tons per acre 1936	1937
Mean yield	25.50	21.40
Response to :—		
Dung (10 tons)	+4.20	+2.04
Sulphate of ammonia (0.6 cwt. N) . .	+7.73	+4.95
Salt (5 cwt.)	+3.12	+4.92
Muriate of potash (1 cwt. K_2O)	+0.22	+0.74
Superphosphate (0.5 cwt. P_2O_5)	−0.45	+0.22
Standard error	±0.675	±0.686

There were good responses to nitrogen (dung and sulphate of ammonia) in both years, the responses being higher in 1936 than in 1937.

There was also a good response to 5 cwt. salt in both years, particularly in 1937, and this is the more remarkable in that in both years the average response to muriate of potash was small and not significant. Superphosphate had little if any effect.

The value of potash as a general rule is of course well established. Its effect in increasing the response to nitrogenous manure (sulphate of ammonia) was strikingly demonstrated in the continuous experiments on Barnfield. There are indications of this effect (and also of a similar effect of salt) in the present experiments, as Table XXX shows.

TABLE XXX

Roots : tons per acre

	Sulphate of ammonia	Mineral Manures None	Potash	Salt	Potash and salt
1936	None	22.55	18.67	22.31	23.03
	0.6 cwt. N . .	26.56	28.00	30.16	32.76
	Increase	+4.01	+9.33	+7.85	+9.73
1937	None	16.99	18.51	20.64	19.56
	0.6 cwt. N . .	18.78	21.49	27.71	27.53
	Increase	+1.79	+2.98	+7.07	+7.97

In both years the addition of either muriate of potash or salt increased the response to sulphate of ammonia, while the highest response was obtained in presence of both potash and salt. In 1936 potash appeared the more effective in this respect, while in 1937 salt was more effective.

The average effects of the treatments on tops were similar to those on roots. The experiments also provide information on the question whether it is worth while applying artificials if dung is being used.

Response to	1936 Dung		1937 Dung	
	Absent	Present	Absent	Present
Sulphate of ammonia ..	+7.87	+7.59	+5.80	+4.11
Salt	+4.09	+2.16	+5.22	+4.61
Standard error	±0.955		±0.970	

Both sulphate of ammonia and salt gave substantial increases in the presence of dung, although the increases were somewhat less than those obtained in the absence of dung.

Experiments in conjunction with Mr. J. R. Bond at Oakerthorpe, Derby, in 1932, 1933 and 1934 tested the effects of dung, sulphate of ammonia and potash salt. The results are similar to those obtained at Rothamsted.

TABLE XXXI

	Mangolds roots: tons per acre 1932	1933	1934
Mean yield	31.20	20.58	19.56
Response to :—			
Dung (15 tons)	+8.13(1)	+4.21	+9.75
Sulphate of ammonia (0.6 cwt. N)	+8.76*	+1.42	+2.21
30% Potash Salt†	+5.63	+3.68	+6.82
Standard error	±0.354	±0.976	±0.856

* 1.2 cwt. N.
† 1932, 2.4 cwt. K_2O., 1933, 0.9 cwt. K_2O., 1934, 1.2 cwt. K_2O.
(1) S.E.=±0.488.

There were large responses to dung and potash salt in all three years. The double dressing of ammonia gave a good response in 1932, while the single dressings in 1933 and 1934 were not so effective.

Responses to sulphate of ammonia

1932 Potash salt		1933 Potash salt		1934 Potash salt	
Absent	Present	Absent	Present	Absent	Present
+7.27	+10.27	+1.81	+1.03	+0.98	+3.44
±0.498		±1.38		±1.21	

In 1932 and 1934 the presence of potash salt increased the response to sulphate of ammonia, agreeing in this respect with the Rothamsted experiments.

	1932		1933		1934	
	Dung		Dung		Dung	
	Absent	Present	Absent	Present	Absent	Present
Response to : Sulphate of ammonia ..	+11.74[1]	+5.79[1]	+2.28	+0.56	+3.02	+1.39
Potash salt ..	+6.18[2]	+5.08[2]	+4.90	+2.44	+9.26	+4.38
	([1]) ±0.690 ([2]) ±0.498		±1.38		±0.856	

As in the Rothamsted experiments both sulphate of ammonia and potash salt produced increases in the presence of dung, while in the absence of dung larger (in some cases considerably larger) increases were obtained.

Potatoes

For the past thirteen years experiments on the manuring of potatoes have been made at Rothamsted and Woburn and on potato growing farms in different parts of the country : some of the recent results are collected in Table XXXII.

TABLE XXXII

Main Crop Potatoes. Summary of Experiments 1932-37[1]
Mean Yields and Mean Increases, Tons per Acre

	Yield without nitrogen	*Increase for* N_1	*Increase for* N_2	Yield without phosphate	*Increase for* P_1	*Increase for* P_2	Yield without potash	*Increase for* K_1	*Increase for* K_2
MINERAL SOILS									
No dung									
Light (1 expt.) ..	11.84	+0.60	+0.84	—	—	—	12.34	−0.08	+0.03
Medium (1 expt.)	12.25	+1.03	+1.91	12.42	+0.80	+1.63	12.87	+0.23	+0.85
Heavy (2 expts.) ..	10.61	+1.19	+1.47	—	—	—	11.59	−0.21	−0.08
With Dung									
Light (2 expts.) ..	7.16	−0.20	−0.17	—	—	—	6.98	−0.07	+0.24
Medium (2 expts.)	10.86	+1.32	+1.50	11.49	+0.60	+0.32	11.55	+0.53	+0.21
Heavy (1 expt.) ..	10.24	+2.34	+3.22	—	—	—	12.07	+0.16	−0.10
FENLAND SOILS									
No Dung									
Light (6 expts.) ..	7.01	+1.11	+1.53	6.96	+1.23	+1.56	6.16	+2.08	+2.67
Heavy (5 expts.) ..	10.11	+2.10	+3.13	9.92	+2.54	+3.26	11.00	+0.28	+0.46
With Dung									
Light (2 expts.) ..	8.08	+1.16	+1.17	8.43	+0.36	+0.93	8.09	+0.75	+1.55
Heavy (1 expt.) ..	12.73	+1.59	+2.56	13.60	+0.55	+0.99	13.49	+0.58	+1.29

[1] Dressings per acre :
N_1 = 1½ cwt. sulphate of ammonia (0.3 cwt. nitrogen).
N_2 = 3 cwt. sulphate of ammonia (0.6 cwt. nitrogen).
P_1 = 4½ cwt. superphosphate (0.75 cwt. P_2O_5).
P_2 = 9 cwt. superphosphate (1.5 cwt. P_2O_5).
K_1 = 1½ cwt. sulphate of potash (0.75 cwt. K_2O).
K_2 = 3 cwt. sulphate of potash (1.5 cwt. K_2O).

They show that one dose of the fertilizer usually gives a good result even when farmyard manure is also supplied but the double dose may not give a sufficiently greater increase to pay for the extra manure. Nitrogen (sulphate of ammonia) has given the most consistent increases both on mineral and on fenland soils, whether dung is added or not. Phosphate and potash have given marked increases on fenland soils, greater indeed than on the mineral soils.

The results thus resemble those for sugar beet in that the effects of phosphatic and potassic manures vary considerably from soil to soil: attempts are being made in the Chemical Department to find some chemical method of ascertaining beforehand whether the soil is or is not likely to respond. This is well illustrated by the following pair of results obtained in our "3 x 3 x 3" experiments, one obtained on a light, the other on a heavy fen soil; both soils responded to nitrogenous fertilizer; the light soil responded to potash but not to phosphate while the heavy soil responded to phosphate but not to potash.

TABLE XXXIII

Effect of Phosphate

	Yields, tons per acre ±0.354 Heavy Soil (Little Downham, 1934) Marked response				*Yields, tons per acre* ±0.970 Light Soil (Thorney, 1934) No response			
Super-phosphate cwt. per acre	No sulphate of ammonia	Sulphate of ammonia		Mean ±0.204	No sulphate of ammonia	Sulphate of ammonia		Mean ±0.560
		1½ cwt.	3 cwt.			1½ cwt.	3 cwt.	
0	10.0	12.3	12.9	11.7	6.3	7.1	9.3	7.6
4½	13.8	15.8	16.8	15.5	5.5	8.4	9.1	7.7
9	14.8	16.7	18.4	16.6	8.6	7.3	8.9	8.2
Mean ±0.204	12.9	14.9	16.0	14.6				
Mean ±0.560					6.8	7.6	9.1	7.8

TABLE XXXIV

Effect of Potash

	Yields, tons per acre ±0.354 Heavy Soil (Little Downham, 1934) No response				*Yields, tons per acre* ±0.970 Light Soil (Thorney, 1934) Clear response			
Sulphate of potash, cwt. per acre	No Sulphate of ammonia	Sulphate of ammonia		Mean ±0.204	No Sulphate of ammonia	Sulphate of ammonia		Mean ±0.560
		1½ cwt.	3 cwt.			1½ cwt.	3 cwt.	
0	12.3	14.5	15.8	14.2	5.0	5.9	9.5	6.8
1½	13.2	15.4	16.0	14.8	7.9	8.2	8.4	8.1
3	13.1	15.0	16.4	14.8	7.5	8.8	9.5	8.6
Mean ±0.204	12.9	14.9	16.0	14.6				
Mean ±0.560					6.8	7.6	9.1	7.8

The contrast is shown perhaps more clearly in Table XXXV when all levels of nitrogen are grouped together so as to show only the potash and phosphate effects :—

TABLE XXXV

	Yields, tons per acre ±0.354 Heavy Soil (Little Downham, 1934) Phosphate response				*Yields, tons per acre* ±0.970 Light Soil (Thorney, 1934) Potash response			
Sulphate of potash, cwt. per acre	No Super-phosphate	Super-phosphate		Mean ±0.204	No Super-phosphate	Super-phosphate		Mean ±0.560
		4½ cwt.	9 cwt.			4½ cwt.	9 cwt.	
0	11.3	14.8	16.5	14.2	7.0	6.5	6.9	6.8
1½	12.1	16.0	16.4	14.8	8.0	8.1	8.2	8.1
3	11.8	15.6	17.1	14.8	7.8	8.4	9.6	8.6
Mean ±0.204	11.7	15.5	16.6	14.6				
Mean ±0.560					7.6	7.7	8.2	7.8

Interactions. It not infrequently happens that a fertilizer acts better in presence of another than when it is used alone. Occasionally the reinforcement is very pronounced as in the following experiments on potatoes at Thorney, Isle of Ely, in **1933** :—

TABLE XXXVI

Mean yield, tons per acre	Addition given by sulphate of ammonia, tons per acre		Mean yield, tons per acre	Addition given by sulphate of ammonia, tons per acre	
	Used alone	With potassic fertilizer		Used alone	With phosphatic fertilizer
9.00	0.43	1.72	14.52	1.05	4.00
10.17	0.41	1.86	14.11	0.47	3.33

The figures in the upper line are in presence of farmyard manure : those in the lower line in absence of farmyard manure.

The total number of interactions of this kind obtained up to the present (1925-1937 inclusive) is shown in Table XXXVII.

TABLE XXXVII

	Nitrogen and potash interaction	Nitrogen and phosphate interaction	Phosphate and potash interaction
Total number of experiments	55	40	39
Positive interactions ..	35	29	27
No interaction or negative	20	11	12

Most of the interactions, however, are not statistically significant but all significant results are positive.

The proportion of ware. Mr. Garner has recently collected all the results relating to the percentage of ware and finds that fertilizers have a very marked effect in raising the proportion of ware in cases where the percentage without manure is low, but not where it is high.

TABLE XXXVIII

Percentage Ware

Mean Effects of Nutrients and Organic Manures Grouped according to Initial Percentage Ware

Initial percentage ware (no manure)	Increase due to						Total expts.
	N	P	K	Organic	Dung	NPK	
Over 90 ..	−0.4	−1.1	+0.6	−0.3	—	—	9
80 ..	+1.2	−1.1	+1.5	+0.7	—	—	34
70 ..	+2.6	+3.6	+8.7	−1.0	+5.5	+4.0	29
60 ..	+0.7	+6.8	+8.4	+2.8	+15.2	+4.4	29
50 ..	+16.8	+5.9	+15.8	—	+25.9	+22.4	9
Under 50 ..	—	—	+20.3	—	+34.2	—	3
Weighted mean	+2.0	+2.1	+7.6	+1.2	+15.3	+6.9	113

KALE

Marrow stem kale is one of the most useful of fodder crops and one of the best converters of cheap fertilizer nitrogen into valuable protein food for animals. Numerous experiments on the manuring of kale have been recorded in previous Reports : for convenience they are collected in Table XXXIX : they show that responses continue even up to 6 cwt. fertilizer per acre and whether dung is given or not. One of the experiments (Woburn 1932) shows that a dressing of 15 tons of dung had about the same effect as 2 cwt. sulphate of ammonia per acre.

TABLE XXXIX

Effect of Nitrogenous Fertilizers on Kale

Year	Yield, tons No nitrogen	Increase, tons per acre[1]						Standard error ±	Form of nitrogen
		1	2	3	4	5	6		
ROTHAMSTED									
1932	12.6		2.8					0.54	Sulphate of ammonia
1933	9.0					2.5([2])		0.39	Sulphate of ammonia
1936	11.3		1.5		2.4			0.65	Sulphate of ammonia
WOBURN									
1932	18.3		1.3					0.92	Sulphate of ammonia
1932	13.3	4.5	6.4		11.1			1.01	Sulphate of ammonia
1932	19.2	2.0	4.5		9.6			1.01	Sulphate of amm. (3).
1936	8.2		2.0		6.4			0.66	Sulphate of ammonia
MIDLAND COLL.									
1931	15.3	2.9	3.8		7.1			0.95	Nitrate of soda (3).
1932	22.8		1.6		3.8			0.81	Nitrochalk (3).
1933	27.5			5.4			8.5	1.10	Nitrochalk (3).
1934	30.7			2.4			4.5	1.32	Nitrochalk (3).
1935	33.4			1.3			4.0	1.15	Nitrochalk (3).
1936	30.1			2.8			6.7	1.54	Nitrochalk (3).
DERBY									
1935	8.2		4.0		7.9			0.67	Sulphate of ammonia
WINCHESTER									
1933	12.1		0.3		−1.6			0.64	Sulphate of ammonia

(1) The headings 1, 2, 3, etc., refer to the number of cwt. per acre of nitrogenous fertilizers supplied.
(2) Other plots received respectively 10 and 15 cwt. per acre sulphate of ammonia and gave increases over no nitrogen of 2.6 and 2.5 tons per acre.
(3) All plots received farmyard manure.

TABLE XL

Kale (tons per acre)

	No sulphate of ammonia	Sulphate of ammonia		
		1 cwt.	2 cwt.	4 cwt.
No dung	13.3	17.8	19.7	24.4
15 tons dung	19.2	21.2	23.7	28.7
Increase for sulphate of ammonia (no dung)	—	4.5	6.4	11.1
Further increase for 15 tons farmyard manure	—	3.4	4.0	4.3

No farmyard manure is given except where stated.

BEANS

Field beans have not formed the subject of many experiments and yet they have considerable value as fodder. During the past four years (1934-1937) several manuring experiments have been made, and in them were included comparisons of narrow and of wide spacing respectively.

The effects of the fertilizer treatments are shown in Table XLII : the summary is shown in Table XLI.

TABLE XLI

Beans grain (cwt. per acre)

Responses to treatments

Year	Dung (10 tons per acre)	Nitro-chalk (0.4 cwt. nitrogen per acre)	Muriate of potash (1 cwt. K_2O per acre)	Super-phosphate (0.6 cwt. P_2O_5 per acre)	Standard error	Mean yield
1934	+1.9(1)	+1.1	+0.5	—	±0.91	18.7
1935	+5.6(1)	+1.2	+2.7(1)	−2.0	±1.20	21.0
1936	−0.1	−2.2(1)	−0.3	+0.3	±0.61	16.8
1937	+2.0	+0.4	+2.4	+3.3(1)	±1.34	29.0

(1) Significant effect.

In 1936 the crop was weedy and the yields were poor—only 16 to 18 cwt. grain per acre. There were no treatment effects except a significant depression of yield on plots receiving nitrochalk, which may have been due to a stimulation of the weeds.

In each of the other years dung has given an increased yield, though only in 1935 was the effect large. Nitrochalk has had little effect in the other years, while potash gave increases in 1935 and 1937, and superphosphate increased the yield in 1937.

The results suggest that the bean crop is not very responsive to fertilizers. While farmyard manure has given increases there seems no reason to invoke any special action beyond what is due to the nutrients present.

The narrow spacing (16-18 ins.) proved superior to the wide spacing (24 ins.) in both years (1935 and 1937) in which it was tested, giving increases of 2.8 cwt. in 1935 and 7.7 cwt. in 1937. The mean yield on the 1936 spacing experiment was only 14.8 cwt. ; the yields with the three spacings were :

8 ins.	15.4 cwt.
16 ins.	14.8 cwt.
24 ins.	14.2 cwt.

small differences, but in the same direction as above.

The narrow spacing might have been supposed more responsive to manures than the wide, on account of extra demand for nutrients : the results, however, tend rather in the opposite direction. The responses in cwt. per acre to treatments at the two spacings were :

D

Response to	1935 Spacing		1937 Spacing	
	18 ins.	24 ins.	16 ins.	24 ins.
Dung	+3.8	+7.4	+2.5	+1.4
Nitrochalk	0.0	+2.4	−0.4	+1.2
Potash	−0.4	+5.8	+1.8	+3.1
Superphosphate	−3.0	−0.9	+2.7	+3.8
Standard error	±1.69		±1.89	

The standard errors per cent. per plot ranged from 10.3 to 18.4. Beans have proved more variable than most farm crops in our experiments.

TABLE XLII

Effect of Various Manures on the Yield of Beans (cwt. per acre). Rothamsted 1934-1937

Year	Dung			Nitrochalk			Superphosphate		Muriate of potash			Drill width		Standard error
	No dung	D_1	D_2	No nitrogen	N_1	N_2	No phosphate	P_1	No potash	K_1	K_2	18ins.	24 ins.	±
Grain :														
1934	17.2	18.9	20.1	18.2	18.7	19.3	—	—	18.7	17.8	19.4	—	—	0.647
1935	18.2	23.8	—	20.4	—	21.6	22.0	20.0	19.6	—	22.4	22.4	19.6	0.845
1936	16.8	16.8	—	17.9	—	15.7	16.6	16.9	16.9	—	16.6	—	—	0.430
1937	28.0	30.0	—	28.8	—	29.2	27.4	30.7	27.8	—	30.2	32.9	25.2	0.947
Straw :														
1934	13.4	14.6	16.7	14.9	14.7	15.3	—	—	15.2	14.3	15.3	—	—	0.549
1935	21.4	31.2	—	25.1	—	27.5	25.4	27.2	24.9	—	27.7	28.6	24.0	0.892
1936	31.2	34.5	—	32.0	—	33.8	32.6	33.1	32.0	—	33.8	—	—	—
1937	29.4	32.0	—	30.5	—	30.9	29.5	31.9	29.4	—	32.1	34.2	27.2	—

$D_1 = 7\frac{1}{2}$ tons 1934, 10 tons 1935-1937. $N_1 = 0.4$ cwt. Nitrogen. $K_1 = 1.0$ cwt. K_2O. $P_1 = 0.6$ cwt. P_2O_5 per acre.
D_2, N_2, K_2, applications double D_1, N_1, K_1. Narrow drill 16 inch in 1937.

POSSIBLE NEW CROPS: SOYA BEANS AND MAIZE

In 1934 experiments on the possibility of finding varieties of maize and soya beans suited to this country were begun at Rothamsted and Woburn by Prof. W. Southworth, who had been very successful in similar work at the Manitoba Agricultural College.

Maize

Seed of Manitoba Flint and Manalta were obtained from the Manitoba Agricultural College where they originated and sown both at Rothamsted and Woburn in the spring of 1934. The season was hot and sunny. The seed ripened well and was saved for 1935. This season also was sufficiently good to allow of ripening and by this time it was clear that Manalta was in our conditions earlier than Manitoba Flint. The latter, therefore, was discarded.

1936 was cloudy and wet; during July and September, two important months for both maize and soya beans, there were no less than 152 hours less sunshine than the normal; seeding was, therefore, not good. 1937 was better and at Woburn we obtained a good crop of well ripened Manalta seed.

Meanwhile two varieties of sweet corn, Golden Bantam, from the Manitoba Agricultural College, and Dorinni from the Central Experiment Farm, Ottawa were grown at Rothamsted in 1935. The former proved less suitable and was, therefore, discarded. The two varieties had been grown side by side and cross pollination took place. The resulting seed was, therefore, no longer the pure Dorinni but a back cross, Golden Bantam having been one of the parents of Dorinni. This new strain, which we call Rothamsted Sweet Corn, is now being grown under a variety of conditions.

Soya Beans

In the spring of 1934 two varieties were planted, Manitoba Brown and Mandarin; the former being a semi-dwarf, early maturing, brown-seeded variety, developed at the Manitoba Agricultural College, while the latter is a medium sized variety with yellow seeds, much later in maturing.

Manitoba Brown ripened satisfactorily but Mandarin did not. It was, therefore, discarded.

In 1935 three other varieties were sown in addition to Manitoba Brown, namely, The Jap, an early maturing dwarf plant with pale green seeds; J. Yellow, a late maturing plant with yellow seeds; and Black, a medium sized plant with black seed coming later than Manitoba Brown. Frosts in the middle of May severely checked all four varieties but the plants recovered later and gave a fair yield. Manitoba Brown and Jap came out best, followed by Black but J. Yellow was too late to ripen properly. At Woburn also Manitoba Brown did well.

In 1936 at Rothamsted a May frost again checked the plants and a severe hail storm on June 21st did much damage. The yield of seed was small, nevertheless the maturity was good. At Woburn the plants suffered from rabbits, hares and birds.

In 1937 some more varieties were received from the Manitoba Agricultural College, one of which, Tokio, is promising both in yield and early maturity; the seed is dark but it may be possible to remedy this by suitable hybridisation and selection.

Prof. Southworth has now more assistance than before and has been able to commence more intensive study of the morphological and physiological characters of soya bean and he is trying to obtain new varieties better suited to our conditions than the existing sorts. We have been fortunate in securing the help of a collaborator in South Africa who plants the seeds during our winter and returns them to us in time for planting during our summer; we thus secure two crops in one year which saves a good deal of time in making selections.

Vernalisation did not prove helpful either for soya beans or maize.

PYRETHRUM

In view of the importance of pyrethrum as an insecticide and of the fact that it grows well on light sandy soil, a number of experiments have been made to see if by manuring the yields can be raised to levels at which they would become remunerative without at the same time lowering the insecticidal efficiency of the crop.

The experiments were made at Woburn, and were continued over four years: both lime and fertilizers increased the yield of flowers and of pyrethrum, the substance which measures the insecticidal value, but in some seasons the effects were only slight.

The effect of lime—2.9 tons of ground lime applied in the first year only—was as shown in Table XLIII.

TABLE XLIII

Effect of Lime

	1934	1935	1936	1937
	Dry flowers (cwt. per acre)			
No lime ..	4.70	6.72	4.93	4.26
Lime ..	5.14	7.32	5.28	4.86
Increase..	+0.44	+0.60	+0.35	+0.60
Standard errors	±0.29	±0.37	±0.33	±0.45
	Pyrethrin I (per cent. of flowers)			
No lime ..	0.528	0.449	0.406	0.520
Lime ..	0.559	0.472	0.420	0.545
Increase..	+0.031	+0.023	+0.014	+0.025
Standard errors	±0.020	±0.021	±0.023	±0.018

Lime produced a slight increase—about 1 per cent. each year—in yield and in pyrethrin I. Lime also appears to have had a beneficial effect on plant survival. The percentages of plant failures in the last two years are as follows :

	1934	1935	1936	1937
No lime ..	8.1	5.5	23.3	31.2
Lime ..	7.9	5.7	16.9	25.1

The yield of dry flowers in the first year (1933) was small: it rose to a maximum in 1935 and thereafter decreased.

The manures tested were fish manure (0.2 cwt. nitrogen per acre) and complete artificials, sulphate of ammonia (0.2 cwt. nitrogen) superphosphate (0.2 cwt. P_2O_5) and muriate of potash (0.25 cwt. K_2O) per acre.

The manures applied every year gave a significant increase in flowers in 1934 and 1937 but had little effect in 1935, while in 1936 there was a slight but not significant decrease. In the two years in which the manures produced an increase, fish manure gave higher yields than artificials though the differences were not significant.

The manures had no effect on pyrethrin I contents in 1934 and 1935 but produced significant increases in 1936 and 1937.

The results are shown in Table XLIV.

TABLE XLIV

Year	No manure	Artificials	Fish manure	Artificials+ fish manure	Standard errors	Mean of manures
		Dry flowers (cwt. per acre)				
1934	4.94	5.28	6.03	5.60	±0.404	5.64
1935	6.62	6.84	6.38	7.42	±0.520	6.88
1936	5.27	5.00	4.76	4.78	—	4.85
1937	4.17	4.58	5.25	5.49	—	5.11
		Pyrethrin I (per cent. of flowers)				
1934	0.55	0.54	0.54	0.54	±0.028	0.54
1935	0.46	0.45	0.45	0.46	±0.025	0.45
1936	0.38	0.47	0.46	0.45	±0.033	0.46
1937	0.51	0.57	0.55	0.55	—	0.56

ELEMENTS REQUIRED IN SMALL QUANTITIES ONLY

Boron

It is now nearly 20 years since Dr. K. Warington showed in our laboratories that boron is essential for plant growth. The various symptoms of boron deficiency and the pathological results associated therewith are now known for certain crops, particularly sugar beet, apples, swedes and others; during 1936-1937 studies have been made of the effect of boron deficiency on carrots. Our earlier experiments also show that field beans respond to small dressings of boron. The time is undoubtedly ripe for systematic field experiments on the possibilities of boron as a fertilizer: only in this way can definite and trustworthy information be obtained.

Manganese

Manganese deficiency results in pathological conditions in oats ("Grey speck"), and sugar beet ("Speckled yellow"), and peas. Chemical studies have been made to find some way of estimating the availability of the manganese. Soils on which these diseases occurred were of the same general type, viz., reclaimed heaths rich in organic matter and made alkaline by liming. They contained little or no exchangeable manganese, except on plots where additions of manganese sulphate had controlled the diseases in the field.

There are good grounds for believing that Marsh Spot disease in peas is connected with manganese deficiency, but certain soils from the Romney Marsh area on which the disease occurs contain appreciable amounts of oxides of manganese. The disease never occurred on an acid soil though a few of the alkaline ones also gave healthy peas. The acid soils naturally contained more readily soluble manganese than the alkaline ones, but it was not possible among the alkaline soils to distinguish by analysis the two or three soils which gave peas free from the disease.

Pot cultures in 1937 confirmed the results of preliminary tests in 1936. On several soils from Romney Marsh, Lincolnshire, and Warwickshire, and on sand-bentonite mixtures, peas developed Marsh Spot in the control pots but not in those treated with moderate dressings of manganese sulphate. Small dressings of manganese sulphate sufficed to control the disease in the light soils and the sand-bentonite mixtures. The manganese contents of the pea plants, both at an early stage of growth and at maturity, were but slightly altered by the added manganese. In the Romney Marsh soils the readily soluble manganese of the soil was also but little influenced by the additions of soluble manganese.

Other elements apparently needed in small amounts have been studied, including zinc, cobalt and nickel. Some Dartmoor soils on which sheep do not thrive, contain as little cobalt as the well-known "sheep-pining" soils of New Zealand. Experiments have also been continued with molybdenum which has interesting and striking effects on plant growth. A beginning has been made with the investigation of copper salts which in certain soil conditions in Holland and in Florida give remarkable increases in crop.

CHEMISTRY DEPARTMENT

The extension of the Chemical laboratories gives special interest to the work being done there and to the developments it is proposed to make as soon as the new buildings are completed.

Soil Fertility.—The numerous field experiments on commercial farms are used as a basis for testing laboratory methods of soil analysis for fertilizer requirements. The 1936 and 1937 results with sugar beet showed much larger responses to fertilizers than in any of the three preceding dry seasons, and in consequence it was for the first time possible to make adequate tests of the success of laboratory methods in forecasting the responses of crops to added fertilizers. For nitrogen there was a fair correlation in 1936 between the response to sulphate of ammonia and the amount of inorganic nitrogen obtained in the soil samples after incubation. For phosphoric acid the fraction soluble in acetic acidwas significantly related to the responses to superphosphate, the agreement being better in 1936 than in 1937. The more commonly used citric acid method was less successful. For potash neither the water-soluble nor the acetic acid-soluble fractions were significantly related to the field responses in 1936 though they were in 1937.

When the data were set out in groups according to textural classes of soils it became clear that fertilizer recommendations, whether based on soil analyses or not, must be adjusted to the soil texture, for it happened that on the heavy soils the sugar beet yield was depressed by potassic fertilizers in 1936, in spite of the fact that some methods of soil analysis actually in use always give lower results for heavy than for light soils. The field experiments hold out considerable promise that soil analysis may give useful results for soils of normal fertility, provided the methods are standardised by field trials on related soils.

During 1937 soils were collected from a series of field experiments on potatoes carried out at over twenty centres and investigations are being made on the lines set out above. For both potash and phosphate the field results agree fairly well with the analytical data.

Preliminary trials have been made of very rapid methods of soil analysis which are now proving extremely popular in the United States. One of these methods agreed well with the standard method of determining acetic acid-soluble phosphoric acid and potash, except for calcareous and fen soils.

Basic Slags.—As in the preceding years, work was carried out for the Permanent Committee on Basic Slag to compare the agricultural value of medium-soluble slags with the better known high- and low-soluble slags. In Scotland Prof. McArthur carried out field experiments with several kinds of slag, each at two or more rates of dressing. Samples of the produce were analysed at Rothamsted to determine the recovery of phosphoric acid in the crops. The experiments again showed that, in effects on yield and recovery of phosphoric acid, the available phosphoric acid could be expressed as a first approximation by the amount of citric-soluble phosphoric acid applied. Dressings of medium-soluble and low-soluble slags gave similar results to much smaller amounts of high-soluble slag providing the same amount of citric-soluble phosphoric acid. The experiments showed that the yields of swedes approached a limit for applications of the order of 7 cwt. of high-soluble basic slag per acre. Earlier experiments with slags at a single heavy rate of application had failed to differentiate clearly between the various types of slag tested, because the dressings used raised the yield towards this limit. In pot cultures at Rothamsted an attempt was made to compare basic slags under widely contrasted conditions of crop, soil and method of incorporating the basic slag with the soil. Some of the **1936** experiments were carried on into **1937** to compare clover, timothy and rye grass. The final data are not yet available, but it was apparent during growth that all three crops grew well without added phosphate in a soil which had failed to produce good swede crops in the field in **1935** or good growth of turnips in pots in **1936**, unless phosphates were added. Grasses and clover can thus use soil phosphates which are not available to swedes. This fact may explain why the residual effects on oats and hay in the field experiments have been so small by comparison with the immediate effects of the basic slags on swedes.

A new silico-phosphate has been isolated from some medium-soluble slags and shown by optical and X-ray methods to be very similar to, if not identical with, one of two silico-phosphates recently prepared synthetically in Germany.

The nature of the phosphorus and potassium compounds in soil.—A considerable proportion—some **25** per cent.—of the total phosphorus is present in soils in organic combination. Methods have been developed for determining its amount ; its form has not yet been established, but it is very stable and is probably not available to plants.

In acid soils most of the phosphate added in fertilizers appears to pass over in a few years to unavailable iron phosphates. In neutral soils the reserves may, however, be built up as calcium phosphates.

Even although potassium forms no simple insoluble compounds a good deal of the potash added to many soils may be locked up in inert forms which are neither available to plants nor capable of being washed down into the lower depths of soil. On the other hand, plants can undoubtedly utilise potassium from forms other than the readily soluble exchangeable potassium. It is hoped partly by chemical work and partly by empirical methods to define more closely the conditions under which potassium added in fertilizers will become more highly effective.

The nature of the inorganic soil colloids.—These substances—often regarded as the same as the clay—play an extremely important part in soil fertility. X-ray studies are being made to find out more about their constitution. The X-ray diagrams of soil colloids from a widely differing collection of soils all gave the same type of pattern with only minor variations. More detailed work has, therefore, been undertaken on minerals related to those found in clays with the object of discovering sharper criteria for differentiation.

BACTERIOLOGY DEPARTMENT

This department is also to be housed in the new wing, it having entirely outgrown the old laboratory erected in 1906 as the result of the James Mason donation.

The work of the department has for some years been devoted to a study of the strains of nitrogen-fixing bacteria that produce nodules on the roots of leguminous plants. The nodule bacteria form a group which can be divided into species, each of which can infect only a small group of legumes. Within these species, strains or varieties of the bacteria can be found that vary very greatly in the benefit which they confer on the host plant ; indeed some strains are purely parasitic and do not benefit the plant at all. Such strains are particularly prevalent amongst pea and clover nodule bacteria, and probably account for the poor growth of clover in certain pastures.

The anatomy of nodules produced by beneficial and "parasitic" strains has been studied and the latter have been found to differ from beneficial nodules in three respects. (1) In young "parasitic" nodules, the cells in which the bacteria lie contain an excessive amount of starch. This may indicate that the bacteria are unable properly to utilise the sugars supplied to them in the nodule. (2) The "parasitic" nodules stop growing at a very young stage and remain small. (3) The bacteria in such nodules very soon begin to attack and destroy the tissues of the nodule in which they lie.

Not only do the "parasitic" strains of bacteria behave abnormally within the nodules, but the plant infected with them also produces some substance, or "antibody," in its root juice that inhibits the growth of the bacteria ; filtered root juice from plants bearing "parasitic" nodules has been found to check growth of the bacteria in culture, whereas juice from uninfected plants or from plants bearing beneficial nodules, has no such effect (Table XLV).

TABLE XLV

Growth of Soybean Nodule Bacteria in Media Containing Root Juices

Medium with juice from plants :—	Millions of bacteria per millilitre
Uninoculated..	1757
Inoculated with beneficial strain	1706
Inoculated with parasitic strain	852

It seems unlikely that we shall be able to alter these fundamental differences so as to make "parasitic" strains of nodule bacteria become beneficial. The problem therefore is to ensure that a leguminous crop becomes infected with beneficial strains. This might be supposed easy, since we possess a practical method of "inoculating" legume seed with the bacteria. But unfortunately the problem is

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complicated by the facts that strains of nodule bacteria compete together in producing nodules, and that this competition almost always ends in favour of the " parasitic " strain. Thus, when pea plants were supplied with a mixture of a good and a " parasitic " strain in equal numbers, 90 per cent. of the nodules were found to have been produced by the latter.

One way to meet the problem of soils infected with " parasitic " strains of nodule bacteria is to seek beneficial strains that can compete effectively with them. The search for " dominant " good clover strains has been successful. Most of the good strains of clover bacteria, like those of peas, seem unable, under normal conditions, to compete with the " parasitic " strains. Table XLVI shows the number of nodules produced by a typical good strain (" 205 "), and a " parasitic " strain (" C "), when the two strains were supplied in equal numbers to clover grown in sand. Two beneficial strains have now been found that can dominate the " parasitic " strain, and the lower line of the table shows the success with which one of these strains (" A "), can compete for nodule production with strain " C."

It has been found that nitrate greatly checks nodule formation by strains " C " and " 205 " but affects strain " A " very much less. It is likely that relative tolerance of nitrogen may explain the dominance of this strain.

The discovery of these "dominant " beneficial strains should enable us to use seed " inoculation " to make clover grow well even in soil heavily populated with a " parasitic " strain.

TABLE XLVI

Results of mixed Inoculation of Red Clover with good and " parasitic" strains

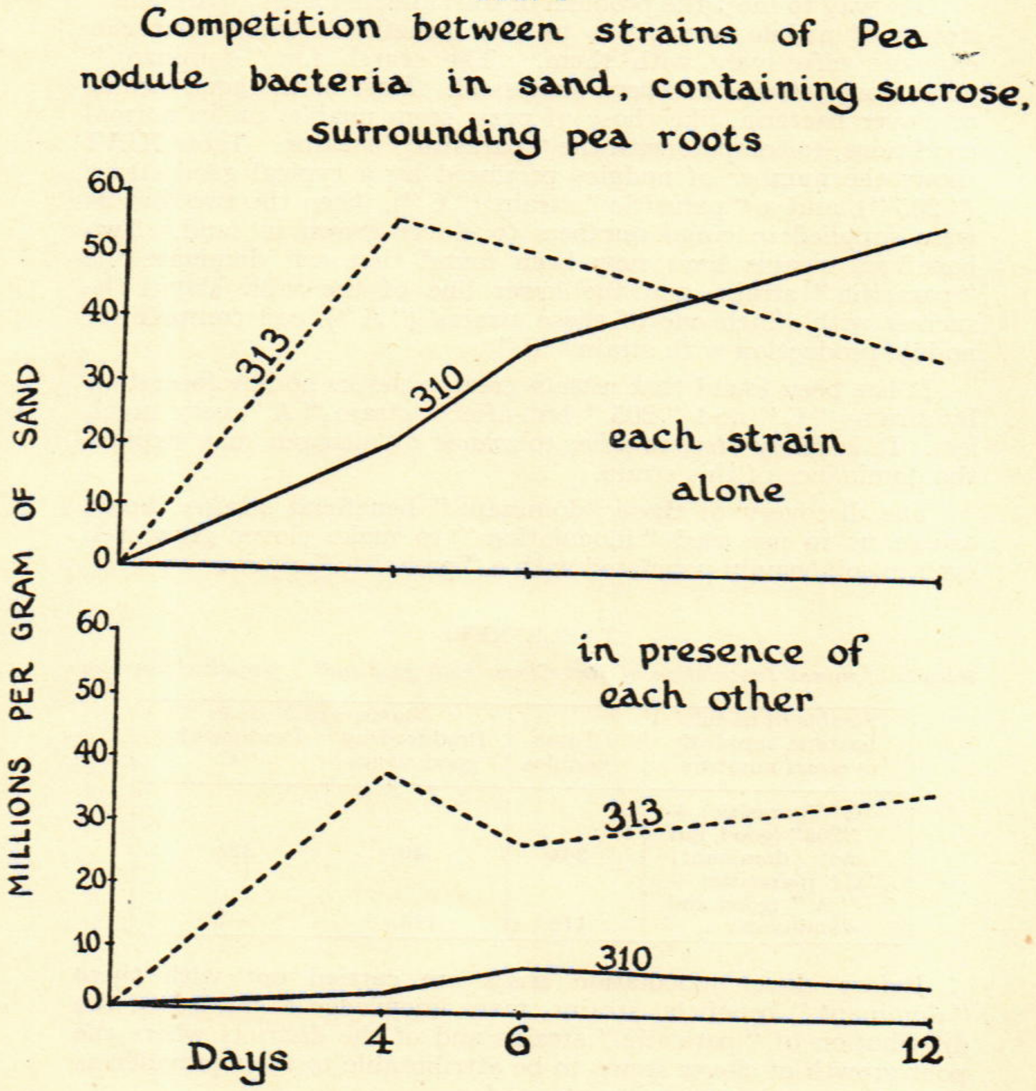
Strains of nodule bacteria supplied in equal numbers	Total nodules	*Numbers of Nodules* Produced by good strain	Produced by " C "
" C " (parasitic) + "205" (good, but not dominant)	364	40	324
" C " (parasitic) + " A " (good and dominant) . .	116	113	3

Before clover inoculation trials are carried out with these " dominant " beneficial strains, more knowledge is needed of the distribution of " parasitic " strains and of the districts where the poor growth of clover seems to be attributable to their prevalence. Such a survey is now being planned.

The dominance which " parasitic " strains show over most beneficial strains seems to be due to competition taking place between the strains outside the plant roots. When peas were grown in sand containing good and " parasitic " strains each in pure culture, both strains were found to multiply in the sand surrounding the roots. But when the two strains were mixed together in the sand, the " parasitic " strain alone increased its numbers and entirely repressed the multiplication of the good strain. (Fig. 1.)

If the chemical state or the physical condition of the sand or soil were suitably modified, it might be possible to encourage the multiplication of the good relatively to the poor strains and so to develop a method of improving the quality of the nodules by manur-

FIG. I



Strain 313, parasitic. Strain 310, beneficial.

ing or soil treatment. Such a method may be needed for legume crops for which " dominant " good strains cannot be found. This idea is being explored.

The competition outside the roots between good and " parasitic " strains of nodule bacteria illustrates the need for more knowledge of the behaviour of soil bacteria in the neighbourhood of plant roots. There is no doubt that roots exert a stimulating effect on bacterial growth. Thus when nodule bacteria were placed in sand without any plants, their numbers after a fortnight rose from 1 to 3 millions per gram of sand, but in sand in which peas were growing, the numbers of bacteria rose in the same time from 1 to 6.1 millions. It is also known that the number of other soil bacteria is much increased by the near presence of plant roots. This large population of micro-organisms amongst the roots must be of great importance in affecting crop growth, and yet it affords an almost untouched field of investigation.

The development in this department of a method for estimating the total numbers of bacteria in soil now makes it possible to investigate the interaction of plant roots with soil bacteria, and it is proposed to undertake this when better laboratory accommodation is available.

There is some evidence that the important problem of clover sickness is related to this growth of micro-organisms upon or near the plant's roots. The fact that clover so often fails when grown too often on the same ground is sometimes attributed to definite fungal or eelworm infections, but there are instances which cannot be attributed to these causes and in which the commencement of the symptoms occurs so early as to exclude the factor of nodule formation by " parasitic " strains. A case at Woburn has been under investigation in collaboration with Dr. Mann. A sterile extract of clover-sick soil from this source has been found so toxic that, in its presence, clover seed is prevented from germinating or killed immediately after germination. It would seem that bacteria growing upon the roots of the preceding clover crop have produced some persistent toxic substance. The nature of this substance and the conditions which make for its formation offer a promising line of investigation which it is proposed to follow up.

But bacteria growing in the proximity of roots also produce effects beneficial to the plant. Thus it has been shown in our earlier work that the growth of root hairs is stimulated by the secretions of nodule bacteria living outside legume roots. This production of growth-promoting substances by soil bacteria may well be of great agricultural importance.

THE WORK OF THE PLANT PATHOLOGY DEPARTMENT AT ROTHAMSTED, 1918-1937

By J. Henderson Smith

The Mycology Department was instituted in 1918, and Dr. W. B. Brierley put in charge, with Miss Jewson as Assistant. At first it was housed in a single room of the old building, but in 1924 moved to the less cramped quarters in the new laboratory which it now occupies. The change gave scope for an increase in the staff, and in 1929 three additional members were added on the formation of the Virus Section. In 1932 Dr. Brierley left to take up the Chair of Agricultural Botany at Reading University ; and a few months later Dr. R. H. Stoughton who had joined the staff as bacteriologist was appointed Professor of Horticulture, also at Reading. On

Dr. Brierley's leaving, the Department was reconstituted as a Department of Plant Pathology with Dr. Henderson Smith as Head. Stoughton who had taken over the duties of mycologist was succeeded by Mr. G. Samuel, who left in 1937 on being appointed Chief Mycologist to the Ministry of Agriculture ; and he was replaced by Mr. S. D. Garrett. In the Virus Section Dr. Caldwell left in 1935 to assume the post of Lecturer in Botany in the South-Western College, Exeter, and his place was filled by Mr. F. C. Bawdén.

The Department has always limited its activities almost entirely to the infectious plant diseases and concerned itself little with other forms, e.g. deficiency diseases. The infectious diseases fall under three main headings, bacterial, fungal and virus, and these are considered separately.

A. Mycology

During his fourteen years' service at Rothamsted Dr. Brierley devoted much attention to the genetical analysis of the fungus Botrytis, and isolated a large number of races. He found that new strains might arise, but they could not be produced at will by varying the conditions. A strain could be temporarily altered by changed conditions, but it returned to its old characteristics on reversion to the old conditions. Apparently pure natural infections often consist of a mixed population of various races but artificial inoculations give rise only to the original infecting race. Dr. Brierley's influence on mycology is not to be measured solely by his original published work : his knowledge and enthusiasm and wide acquaintance with leading mycologists throughout the world contributed largely to establishing the Department in the position which it now holds. Perhaps his most important single contribution was his paper " On a form of *Botrytis cinerea* with colourless sclerotia," (1920) in which is included a scholarly discussion on the significance of mutation in fungi.

In the early years of the Department, with its initially small staff, much time and energy was expended on the attempt to assess the numbers, as well as the kinds, of fungi in soils of different treatment, for which the classical fields of Rothamsted afforded unique material. No very satisfactory conclusions emerged from this work, largely because of the want of adequate methods of assessing numbers. The presence of long threads of mycelium, any fragment of which may give rise to a new colony and the enormous numbers of spores which a single head may produce presented difficulties which were not solved, and have indeed not been fully solved even yet. It was taken up again at a later date by J. Singh, who used the methods developed in the preceding work. He obtained no support for the view that particular manurial treatments produce specific fungus flora. There was a direct correlation between soil fertility as measured by crop growth (e.g. mangolds, wheat) and the number of fungi and actinomycetes in the soil ;

Brierley, W. B. (1920) " On a Form of *Botrytis Cinerea* with Colourless Sclerotia." Phil. Trans. Roy. Soc. Lond. B. 210 pp. 83-114.

Singh, Jagjiwan (1937). " Soil Fungi and Actinomycetes in Relation to Manurial Treatment, Season and Crop." Annals of Applied Biology. XXIV. 154-168.

but he could obtain no conclusive evidence that the numbers in the soil showed a definite periodicity. That there is a correlation between manurial treatment and disease was shown for the potato by Kramer (1930) who found that phosphates reduced and nitrogen increased the liability to attack by *Corticium solani*. Excessive phosphate on the other hand increased the liability to pink rot, while there was no correlation between manurial treatment and blight.

Dr. Henderson Smith joined the staff in 1919, and began a series of studies on the killing of Botrytis spores by chemicals and heat, which are an important contribution to the general theory of disinfection. The types of the killing are different in the two cases. Whereas in heat-death the curve of the rate of destruction is the same at all temperatures,adjustment of the time scalegivingidentical curves, killing by phenol yielded a curve varying in shape from logarithmic to sigmoid according to the concentration of the phenol, the number of the spores and the age. This variation in type was satisfactorily explained on the assumptions that in any assemblage of spores the resistance of the individual varied, and the distribution of the grades of resistance was approximatelynormal; and a formula was arrived at, which expressed the relationship between time of exposure, number of spores, and rate of death. The effect of temperature on the velocity of the reaction by heat was unusually great but conformed to Arrhenius's law. It was pointed out that in all work of this type, e.g. in comparing growth rates, comparison of the times taken to reach a constant result gives more accurate and consistent results than the usual but misleading method of comparing the results reached in constant time.

Miss Muriel Bristol (now Mrs. Bristol Roach) was added to the staff to investigate the possibility that algae, especially green algae, play a significant part in soil fertility, and, using the then novel technique of pure algal cultures, she added much to our knowledge. The mode of life of these organisms differs according as they are on the surface exposed to light or below the surface in darkness. When they occur on the surface, they function like other green plants, transforming by photosynthesis inorganic material into organic material rich in potential energy which is added to the soil when they die. Below the surface they do not necessarily die, but can change their mode of life, becoming saprophytic on some of the organic matter already existing in the soil, as well as assimilating nitrate and phosphate, which they convert into insoluble but

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Smith, J. Henderson. 1921. " The Killing of Botrytis Spores by Phenol." Annals of Applied Biology. VIII, pp. 27-50.

Smith, J. Henderson. 1923. " The Killing of *Botrytis Cinerea* by Heat, with a Note on the Determination of Temperature Coefficients," *ibid*, X, 336-347.

Smith, J. Henderson. 1923. " On the Apical Growth of Fungus Hyphae." Annals of Botany, XXXVII, pp. 341-343.

Smith, J. Henderson. 1924. " On the Early Growth Rate of the Individual Fungus Hypha." New Phytologist. XXIII, pp. 65-78.

Kramer, L. 1930. Unpublished Ph.D. Thesis.

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Roach, B. Muriel Bristol—" On the Carbon Nutrition of Some Algae Isolated from Soil." Annals of Botany, 1927, CLXIII, pp. 509-517.

Roach, B. Muriel Bristol—"On the Algae of Some Normal English Soils." Journ. of Agric. Sci., 1927, XVII, pp. 563-588.

Roach, B. Muriel Bristol—" On the Influence of Light and of Glucose on the Growth of a Soil Alga." Annals of Botany, 1928, CLXVI, pp. 317-345.

readily decomposible forms. They may therefore be regarded as agents which on the one hand increase the stock of energy material in the soil and on the other immobilise soluble nutrients and organic compounds which are available for later use.

At this time Sydney Dickinson was investigating the physiology and genetics of the smut fungi. For this purpose he devised an "isolator" for the isolation of single cells, which depended on a new principle and proved very satisfactory. He studied in detail the cytology of the covered smuts of both oats and barley and the fusion, both within and across the species examined, between the mycelia of different "gender" derived from single sporidial isolations. Incidentally he showed that no infection of oat or barley seedlings by pure cultures of smut fungi results if only one gender (sex) is present, but if two genders are present 90 per cent. infection is obtained.

With the appointment of Mr. Samuel a new orientation was given to the mycological work. Hitherto, it had been—apart from the work on wart disease of potato—somewhat abstract, and divorced from practical agriculture. The accumulated knowledge possessed at Rothamsted of soil conditions, however, seemed to offer an excellent opportunity for the study of crop diseases caused by soil organisms, and Mr. Samuel began with the club-root disease of crucifers. A new mycological glass-house was built in 1935 and the system of heating this and the existing virus houses was reconstituted, a thermostatically-controlled oil-burning plant being introduced to serve all the houses. Samuel worked first on the life-history of the organism producing club-root, and was able to clear up many points which had hitherto been obscure in this much-studied parasite. In the course of this work he devised a method for determining the amount of infection of the root hairs within a week of planting the seed. He showed that the extent of this root-hair infection was a fair index of the amount of disease, which would subsequently appear in the crop, and the method gave him a means of testing the effect of soil treatment in controlling the disease. He confirmed the belief in the value of lime-dressing, but showed that the effect was due not to the calcium content of the dressing but to the alkalinity produced, and that other alkalis, such as potassium or sodium hydroxide, were no less beneficial. This work, which is not yet published, was unfortunately interrupted by his departure to the Ministry of Agriculture; but he indicated a number of problems which should be attacked in any subsequent work on club-root.

Mr. Garrett, who had joined the staff in 1936, was appointed in 1937 to succeed Samuel as mycologist, and has continued in a different field the study of the effect of soil-conditions on disease. The Take-all disease of wheat, or whiteheads as it is also called

Dickinson, Sydney—" Method of Isolating and Handling Individual Spores and Bacteria." Proc. Roy. Soc. Medicine, 1926, XIX, pp. 1-4. (Section of Pathology.)

Dickinson, Sydney—" Experiments on the Physiology and Genetics of the Smut Fungi: Hyphal Fusion." Proc. Roy. Soc. Lond., 1927, B, 101, pp. 126-136, with 1 plate.

Dickinson, Sydney—" Experiments on the Physiology and Genetics of the Smut Fungi: Seedling Infection." Proc. Roy. Soc. Lond., 1927, B., 102. pp. 174-176.

Dickinson, Sydney—" Experiments on the Physiology and Genetics of the Smut Fungi: Cultural Characters. The Effect of Certain External Conditions on their Segregation." Proc. Roy. Soc., Lond., 1931, B., 108. pp. 395-423.

produced by *Ophiobolus graminis* had long been known as a serious disease in other parts of the world, but although present has not been of much significance here until the last few years. It is now becoming of considerable importance, and the reason for the change is not yet clear. It has coincided with the development of mechanised farming, but the connection, if any, has not been established. Garrett is studying the effect of various soil conditions such as moisture, temperature, organic matter content, on the survival period of the fungus, which he has already shown to depend very largely on the environmental conditions. Miss Glynne is studying the fungus *Cercosporella hispotrichoides*, which is in part responsible for " lodging " in wheat, and has during the last eight years maintained a survey of the diseases present in the Rothamsted and Woburn plots.

Wart Disease of Potatoes

The introduction by Miss Glynne (1925) of the " green-wart " method of infection was an important contribution to the study of this disease, since by it susceptibility or immunity could be determined within as many weeks as had hitherto required years. It is now in official use as a routine method and continues to give satisfactory results. It is, however, so sensitive a test that many varieties which were accepted as immune in the field were shown by it to be temporarily susceptible, and the question has arisen whether the laboratory or the field test should be accepted as the criterion of immunity, on which official recognition should be based. On the one hand the Ministry of Agriculture are reluctant to accept as immune varieties which are in the laboratory demonstrably susceptible for a time, lest this susceptibility should lose its temporary character under some conditions of growth or environment ; and on the other it seems unreasonable to reject many promising new varieties on account of susceptibility to an exposure much more severe than could reasonably be expected under field conditions. A final decision has not yet been reached on this matter.

By grafting immune and susceptible plants together W. A. Roach (1927) showed that the immunity is not due to a chemical compound which could traverse the plant and be conveyed from the immune into the susceptible grafts. (*See* Annual Report 1936, p. 85.) Miss Martin (1929) using the "green-wart " method demonstrated the susceptibility to wart disease of numerous species of Solanaceae other than the potato plant, though infection did not

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

Glynne, Mary D.—" Some New British Records of Fungi on Wheat." Trans Brit. Mycolog. Soc. 1936, XX, pp. 120-122.

Glynne, Mary D.—" Infection Experiments with Wart Disease of Potatoes. *Synchytrium endobioticum* (Schilb) Perc." Annals of Applied Biology, 1925, XII, pp. 34-60.

Glynne, Mary D.—" The Viability of the Winter Sporangium of *Synchytrium endobioticum* (Schilb.) Perc." Annals of Applied Biology, 1926, XIII, pp. 19-36.

Glynne, Mary D.—" The Development of *Synchytrium endobioticum* (Schilb.) Perc., in Immune Varieties." Annals of Applied Biology, 1926, XIII, pp. 358-359, with 1 plate.

Roach, W. A.—" Immunity of Potato Varieties from Attack by the Wart Disease Fungus, *Synchytrium endobioticum*, the Fungus causing Wart Disease of Potatoes." Annals of Applied Biology, 1927, XIV, pp. 181-192.

Roach, W. A. and Glynne, Mary D.—" The Toxicity of Certain Sulphur Compounds to *Synchytrium endobioticum*, the Fungus causing Wart Disease of Potatoes." Annals of Applied Biology, 1928, XV, pp. 168-189.

Martin, Mary S.—" Additional Hosts of *Synchytrium endobioticum* (Schilb.) Perc." Annals of Applied Biology, 1929, XVI, pp. 422-429, with 2 plates.

occur from contaminated soil. In spite of much investigation no field method was discovered for treating the soil so as to kill all sporangia of the organism. Treatment with sulphur proved effective on some occasions but not always. It would seem that it is not the sulphur itself which is active, but some derivative from it, and experiments by Miss Glynne and W. A. Roach (1928) suggested that thio-sulphuric acid has a special toxic action over and above that due to the hydrogen ion concentration, which in itself has a definite effect in suppressing the disease when sufficiently high.

For the last few years Miss Glynne has been acting as an official consultant examining all doubtful cases of susceptibility in collaboration with the testing station at Ormskirk and Edinburgh.

B. Bacteriology

In 1927 Mr. R. H. Stoughton began an extensive series of investigations into the "angular leaf spot type" of the Black Arm disease of cotton, the funds for which were provided by the Empire Marketing Board. One of the objects of this enquiry was to see how far the study of a tropical disease can be usefully carried on in a laboratory in England; and the findings were compared with those obtained in the Sudan. In the result it appears clearly that certain types of investigation can be adequately and more economically carried out in this country, and there are many incidental advantages in such co-operation between the tropical and British workers.

In our glasshouses cotton grew well, developing ripe bolls with good lint and healthy seed. The infection experiments were mainly carried out in specially designed chambers, in which the air and soil temperatures and the air moisture and light exposure could be controlled and varied at will within certain limits. The results of the six years' work on the influence of environmental conditions on the disease may be summarised as follows. Primary infection of the cotyledons is usually due to the bacteria (*B. malvacearum*) carried on the outside of the seed and in the fuzz, thorough disinfection of the exterior of the seed resulting in healthy seedlings. Soil temperature affects the amount of primary infection, which is reduced when the temperature is constant above 30° C., but not inhibited wholly at 40°, but is of importance only during the first two or three days after sowing. A regular diurnal variation produced the same effect on infection as a constant temperature near to the mean of the fluctuations. Soil temperature has little effect on secondary infection resulting from spray inoculation of the plants, but

Stoughton, R. H.—"The Morphology and Cytology of *Bacterium malvacearum*." E. F. S. Proc. Roy. Soc. Lond., 1929, B., 105, pp. 469-484, with 1 plate.

Stoughton, R. H.—"The Morphology and Cytology of *Bacterium malvacearum*." E. F. S. Proc. Roy. Soc. Lond., 1932, B. III, pp. 46-52 with 2 plates.

Stoughton, R. H.—"Apparatus for the Growing of Plants in a Controlled Environment." Annals of Applied Biology, 1930, XVII, pp. 90-106, with 2 plates.

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

Stoughton, R. H.—"II. The Influence of Soil Temperature on Primary and Secondary Infection of Seedlings." Annals of Applied Biology, 1930, XVII, pp. 493-503.

Stoughton, R. H.—"III. The Influence of Air Temperature on Infection." Annals of Applied Biology, 1931, XVIII, pp. 524-534, with 1 plate.

Stoughton, R. H.—"IV. The Influence of Atmospheric Humidity on Infection." Annals of Applied Biology, 1932, XIX, pp. 370-377.

Stoughton, R. H.—"V. The Influence of Alternating and Varying Conditions of Infection." Annals of Applied Biology, 1933, XX, pp. 590-611.

https://doi.org/10.23637/ERADOC-1-69

the effect of air temperature is marked, maximum infection occurring at a constant temperature of 35°-38° C., with decreasing incidence at progressively lower temperature. High humidity favours infection, but humidity is of importance only during the first two days after inoculation.

Mr. Stoughton also completed an important study on the morphology and cytology of *B. malvacearum* in which he showed that this bacterium has apparently a sexual stage, though such a complexity is not supposed to occur in bacteria; and that it may dissociate suddenly into new strains which may or may not persist.

C. Virus Disease

The Imperial Agricultural Conference of 1927 recommended that "funds should be provided for the more extended study of the fundamental nature of virus diseases in plants," and the Empire Marketing Board provided means for a considerable development of the virus investigations already being carried out at Rothamsted by Dr. Henderson Smith. Three scientific posts were created, Dr. John Caldwell being appointed in 1929 as Virus Physiologist, Dr. Frances Sheffield as Virus Cytologist and Miss Marion Hamilton (now Mrs. M. A. Watson) as Virus Entomologist. A glass-house for general purposes had already been built in 1927, and a second insect-proofed set of chambers was provided in 1929 for the virus investigations. These were designed to elucidate if possible the ultimate nature of viruses in general and were not concerned with particular diseases of particular crops, for the study of which provision was made in different stations scattered in suitable localities throughout the country.

Dr. Henderson Smith had already published (1928) an account of a mosaic disease of tomatoes, the so-called aucuba disease, caused by a filterable virus closely allied to tobacco mosaic and characterised by the brilliance of its symptoms and the high resistance of the virus to heat, ageing and chemical reagents. He failed to obtain any growth in cell-free media. He had also studied (1928) the transmission of potato mosaic (not then sub-divided into distinct diseases) to tomato and other hosts; and had begun an investigation (later carried further by Dr. Sheffield) into the intracellular inclusions which are characteristic of many virus diseases both in man and animals, and are exceptionally well exhibited in *Solanum nodiflorum* when infected with aucuba mosaic (1930). There is a persistent belief that viruses are an invisible stage in the life-history of visible bacteria, and some support is to be found in the fact that in certain virus diseases specific bacteria are regularly found to be present. Henderson Smith, however, showed (1933) that in tomatoes grown from sterilised seed under aseptic conditions and inoculated with filtered virus juice free from bacteria the disease developed normally without the appearance of bacteria, which should have appeared if they were a stage in the virus multiplication. Miss Jarrett (1930) investigated the streak which occurs in commercial tomato houses, and showed that it is not usually due to a mixture of ordinary mosaic with potato mosaic, as had been supposed, but is an independent virus

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disease resembling tobacco mosaic. She obtained no transmission with *Thrips tabaci*.

In collaboration with D. Mac Clement, Henderson Smith used the gradocol collodion membranes introduced by Dr. Elford to measure the size of certain of the plant viruses. They showed that they differed in size, as do the animal viruses, and arrived at estimates of the actual size of the particles as they occur in infective juice (1932).

Caldwell, in his first papers (1930, 1931) proved that aucuba mosaic does not travel through the plant in the water stream, as was generally assumed, and that it does not normally gain entrance to the water stream, and, if artificially introduced into it, cannot leave it and produce infection. Movement occurred only through living tissue, and the virus cannot pass across a completely dead area. In certain hosts the virus produced only a local reaction at the site of inoculation, in others it might travel through the plant, but produce symptoms only sporadically. Even in tomato the distribution was not uniform, the concentration being higher in the cholorotic areas. The carbohydrate and dry matter content of diseased plants is higher than in normal plants, and respiration is increased, but the nitrogen content was not materially affected.

Caldwell showed that the virus was particulate, and produced some evidence that it was either itself protein or bound to protein, but he was able to show that the claims that had been made at that time to have obtained it in crystalline form were unwarranted. He demonstrated the occurrence of more than one strain of aucuba mosaic, and that the presence of the one produced immunity to the other. He showed that this immunity was in some degree specific against allied strains, but inactive against virus not related to the immunising strain. In a study of the local lesions technique and the effect of adding chemical substances to infective juice he suggested a method by which it was possible to distinguish between the effect on the virus itself and that on the leaves used to test the mixtures.

Birkeland prepared sera against a number of different viruses grown in hosts serologically unrelated, and tested them by the precipitin method. The reactions gave additional evidence that virus is in itself antigenic ; and showed also that cucumber mosaic, tobacco ring-spot and tobacco mosaic are serologically distinct, while aucuba mosaic, tobacco mosaic and probably tomato streak are serologically indistinguishable.

F. C. Bawden joined the staff in 1936, replacing Caldwell, and in collaboration with N. W. Pirie of the Biochemical Laboratory Cambridge, began a series of investigations, which has given and is still giving important results. They (1937) isolated from solanaceous plants infected with three strains of tobacco mosaic virus nucleo-proteins with characteristic optical properties. These are infective at a dilution of $1/10^{10}$ and give specific precipitates with antisera at a dilution of $1/10^{7}$. Solutions of the purified proteins, if the protein content is greater than 2 per cent., separate into two layers, of which the lower is the more concentrated and is birefringent, while the upper shows anisotropy of flow. When centrifuged at

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high speeds these solutions deposit the protein in the form of a birefringent jelly. No enzyme preparation has been found which attacks these proteins at an appreciable rate, but the activity can be affected by a number of chemical agents, and the conditions under which the nucleo-protein complex breaks down were studied. It is suggested that in purified proteins the constituent particles are rod-shaped, and are built up by the linear aggregation of smaller units. There is evidence that in the plant part at least of the virus is not so aggregated.

Similar nucleo-proteins were isolated from cucumber plants infected with Cucumber viruses 3 and 4. These viruses have a host-range distinct from that of tobacco mosaic and differ more widely from the latter than do recognised strains of tobacco mosaic; but they have many properties in common with the latter virus and have common antigens. When precipitated with acid or ammonium sulphate, the proteins form needle-shaped paracrystals, as does tobacco-mosaic virus.

Dr. Sheffield took up the investigation of the inclusion bodies already referred to. It had at one time been asserted that these were actually the virus itself in an amoeboid form; but she showed that they were aggregations of cellular material, which, appearing first as separate small masses circulating in the streaming cytoplasm, coalesced to form eventually the complete inclusions. The process could be followed throughout in the living hair-cells of *Solanum nodiflorum*, and a film was prepared which showed the successive stages from the first appearance of the moving particles shortly after infection to the final completed body, which may eventually break down into protein crystals (1931). She attempted (1934) to parallel these conditions in healthy cells by treatment with substances known to coagulate cytoplasm. Most of the reagents used induced stimulation of the cytoplasmic stream similar to the initial stages of virus infection without real formation of true inclusions but with the salts of molybdic acid all the cytological abnormalities produced by aucuba virus could be imitated in the absence of any virus.

After a study of the development of the assimilatory tissue in Solanaceae she investigated by micropipette injection the susceptibility of the plant cell to virus, and found that individual cells varied greatly in their reaction. She also demonstrated the rôle that the plasmodesms play in the spread of virus by an examination of the stomatal guard-cells. These cells never contain inclusion-bodies, which occur in all other cells, and this immunity was attributed to their lack of plasmodesm connections.

In nature virus disease is commonly transmitted from plant to plant by insects, but how it is accomplished is difficult to understand. It is not, as a rule, simple external transference of infective material on the mouth parts of the insect: there is a specific relationship between the vector and its virus. Mrs. Watson (*née* Hamilton) took up the study of this problem. After developing a method of maintaining insects apart from the living plant (1930), she determined (1935) the volume of liquid taken up by the feeding aphis and the volume returned in the saliva as well as the relations of these volumes in artificial feeding and under natural conditions.

She used different methods of estimation, including imbibition of radio-active solutions, of which very small amounts are measurable, and by the various methods obtained results which are reasonably consistent; and she brought forward evidence that the quantities of virus transferred correspond to the amounts of liquid. This work was followed up by an extensive quantitative study, statistically controlled, of the factors affecting the amount of infection obtained by aphis transmission. Throughout the work she used a virus *Hyoscyamus* III, which she had isolated from an outbreak of disease in a crop of *Hyoscyamus* grown for commercial purposes. A number of striking results appeared from this investigation, e.g. that a maximum percentage infection was obtained during the winter months and a minimum during summer, and that the per-

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Smith, J. Henderson—" Experiments with a Mosaic Disease of Tomato." Annals of Applied Biology, 1928, XV, pp. 155-167, with 1 plate.

Smith, J. Henderson—" The Transmission of Potato Mosaic to Tomato." Annals of Applied Biology, 1928, XV, pp. 517-528, with 3 plates.

Smith, J. Henderson—" Intracellular Inclusions in Mosaic of *Solanum nodiflorum* " Annals of Applied Biology, 1930, XVII, pp. 213-222, with 3 plates.

Smith, J. Henderson—" Streak in Tomatoes Aseptically Grown." Annals of Applied Biology, 1933, XX, pp. 117-122.

MacClement, D. and Smith, J. Henderson—" Filtration of Plant Viruses." Nature, July 23, 1932, 2 pp.

Jarrett, Phyllis, H.—" Streak, a Virus Disease of Tomatoes." Annals of Applied Biology, 1930, XVII, pp. 248-259.

Jarrett, Phyllis H.—" The Rôle of *Thrips tabaci* Lindeman in the Transmission of Virus Diseases of Tomato." Annals of Applied Biology, 1930, XVII, pp. 444-451.

Caldwell, J.—" The Physiology of Virus Diseases in Plants. I. The Movement of Mosaic in the Tomato Plant." Annals of Applied Biology, 1930, XVII, pp. 429-443, with 1 plate.

Caldwell, J.—" II. Further Studies on the Movement of Mosaic in the Tobacco Plant." Annals of Applied Biology, 1931, XVIII, pp. 279-298, with 4 plates.

Caldwell, J.—" III. Aucuba or Yellow Mosaic of Tomato in *Nicotiana glutinosa* and other Hosts." Annals of Applied Biology, 1932, XIX, pp. 144-152, with 1 plate.

Caldwell, J.—" IV. The Nature of the Virus Agent of Aucuba or Yellow Mosaic of Tomato." Annals of Applied Biology, 1933, XX, pp. 100-116.

Caldwell, J.—" V. The Movement of the Virus Agent in Tobacco and Tomato." Annals of Applied Biology, 1934, XXI, pp. 191-205, with 1 plate.

Caldwell, J.—" VI. Some Effects of Mosaic on the Metabolism of the Tomato." Annals of Applied Biology, 1934, XXI, pp. 206-224, with 2 plates.

Caldwell, J.—" VII. Experiments on the Purification of the Virus of Yellow Mosaic of Tomato." Annals of Applied Biology, 1935, XXII, pp. 68-85, with 2 plates.

Caldwell, J.—" On the Interactions of Two Strains of a Plant Virus: Experiments on Induced Immunity in Plants." Proc. Roy. Soc. Lond., 1935, B., 117, pp. 120-139, with 3 plates.

Caldwell, J.—" Factors Affecting the Formation of Local Lesions by Tobacco Mosaic Virus." Proc. Roy. Soc. Lond., 1936, B., 119, pp. 493-507.

Birkeland, J. M.—" Further Serological Studies of Plant Viruses." Annals of Applied Biology 1935, XXII, pp. 719-727.

Bawden, F. C. and Pirie, N. W.—" The Isolation and Some Properties of Liquid Crystalline Substances from Solanaceous Plants Infected with Three Strains of Tobacco Mosaic Virus." Proc. Roy. Soc. Lond., 1937, B., 123, pp. 274-320.

Bawden, F. C. and Pirie, N. W.—" The Relationships between Liquid Crystalline Preparations of Cucumber Viruses 3 and 4 and Strains of Tobacco Mosaic Virus." Brit. Journ. of Exper. Pathology, 1937, XVIII, pp. 275-290.

Bawden, F. C. and Pirie, N. W.—" A Note on Anaphylaxis with Tobacco Mosaic Virus Preparations." Brit. Journ. of Exper. Pathology, 1937, XVIII, pp. 299-291.

Sheffield, F. M. L.—" The Formation of Intracellular Inclusions in Solanaceous Hosts Infected with Aucuba Mosaic of Tomato." Annals of Applied Biology, 1931, XVIII, pp. 471-493, with 7 plates.

Sheffield, F. M. L.—" The Development of Assimilatory Tissue in Solanaceous Hosts Infected with Aucuba Mosaic of Tomato." Annals of Applied Biology, 1933, XX, pp. 57-69, with 3 plates.

Sheffield, F. M. L.—" Experiments Bearing on the Nature of Intracellular Inclusions in Plant Virus Diseases." Annals of Applied Biology, 1934, XXI, pp. 430-453, with 3 plates.

Sheffield, F. M. L.—" The Susceptibility of the Plant Cell to Virus Disease." Annals of Applied Biology, 1936, XXIII, pp. 498-505.

Sheffield, F. M. L.—" The Rôle of Plasmodesms in the Translocation of Virus." Annals of Applied Biology, 1936, XXIII, pp. 506-508, with 1 plate.

Hamilton, Marion A.—" Notes on the Culturing of Insects for Virus Work." Annals of Applied Biology, 1930, XVII, pp. 487-492, with 1 plate.

Hamilton, Marion A.—" On Three New Virus Diseases of *Hyoscyamus Niger*." Annals of Applied Biology, 1932, XIX, pp. 550-567, with 3 plates.

Hamilton, Marion A.—" Further Experiments on the Artificial Feeding of *Myzus Persicae* (Sulz.)." Annals of Applied Biology, 1935, XXII, pp. 243-258.

Watson, Marion A.—" Factors Affecting the Amount of Infection Obtained by Aphis Transmission of the Virus Hy. III." Phil. Trans. Roy. Soc. Lond., 1936, B., 226, pp. 457-489.

Watson, Marion A.—" Field Experiments on the Control of Aphis-Transmitted Virus Diseases of *Hyoscyamus Niger*." Annals of Applied Biology, 1937, XXIV, pp. 557-573.

centage infection (which increases with increased feeding time on the healthy plant) decreases rapidly with increasing times on the infected plant from two minutes to one hour.

In 1932-1933 Mrs. Watson investigated an outbreak of disease in commercial grown *Hyoscyamus*, from which she isolated three viruses, two of them new. In a crop of this kind, which is limited and valuable enough to warrant the expense, it seemed that control by spraying might be practicable ; and it was found that the aphis infestation and consequent infection were reduced thereby. The greatest effect was obtained with weekly sprayings. The influence on yield was less evident, but as a result of weekly spraying in the first year a 30 per cent. increase was obtained in the third crop taken in May of the second year.

As the work of the other Departments has been recently described in full it is not necessary to do more than mention some of the chief lines of work being done in each.

SOIL CULTIVATION AND MANAGEMENT

These investigations are in charge of the Soil Physics Department : an extended account was given in the Report for 1936. Evidence has been accumulated that the purpose of cultivation is to keep down weeds, and operations additional to what is required for this may prove ineffective or even detrimental. The importance of preparing a good seed bed is recognized though some of the rather striking differences in appearance of crop resulting from different methods of preparation do not lead to corresponding differences in final yield.

Soil moisture.—The water relationships of soils have been much studied as being among the most important factors in soil fertility. Water easily moves downwards in the soil under the force of gravity but in other directions its movement is both slow and small in amount. Evaporation seems to occur *in situ ;* plant roots grow to the water, the water does not move to the roots. The investigation of this subject would be greatly facilitated if a trustworthy method were known for the direct measurement of water in the soil and some progress has been made in this direction.

The colours of soils.—Soil surveyors regard the colour of the soil as one of the properties helpful in classification. An improved method of recording colour devised by Dr. Schofield was found to be so valuable that an important firm of instrument makers has acquired the patent and taken over his assistant for the purpose of further developing it.

Soil structure.—Methods are being devised for studying in detail the structure of the soil.

STATISTICAL DEPARTMENT

During the last few years the scope and work of the Statistical Department have changed considerably. The staff had at first to develop methods ; now these methods are used for the solution of problems presented by other departments. At the present time there are three main lines of work :

(1) The improvement of designs for field experiments whereby these may become more useful than at present.

These new methods have proved very popular and are now adopted all over the British Empire and in many other countries of the world. The principle of randomisation introduced by Dr. Fisher, and his subsequent developments of factorial design and of "confounding," have been carried further by Mr. Yates. He has also worked out quasi-factorial and other designs which are being widely adopted in plant breeding and other work which necessitates the testing of a large number of varieties.

(2) Sampling problems such as crop estimation, forecasting, etc. Methods are being worked out experimentally for wheat and a beginning has been made with methods for potatoes and sugar beet.

(3) Methods of analysis have been designed to deal with data collected in various surveys; among these are the results of the Rothamsted Barley Conferences; the enquiry of the Potato Marketing Board on the blackening of potatoes when boiled; and others.

The work of this Department is widely known and attracts much attention from overseas countries. A constant stream of research workers come here for study: last year's group included students from Australia, China, India, Kenya and Iceland. Mr. Yates had a very successful lecture tour in the United States where his work has been attracting considerable attention because of its importance in agricultural planning and development.

MICROBIOLOGY DEPARTMENT

The investigations on biological purification of effluents from sugar beet and milk factories carried out during the past 11 years under the aegis of the Department of Scientific and Industrial Research will be completed during the present year (1938). The work has been done jointly by the Fermentation and General Microbiology Departments and it has proved of great value to the general work of both Departments.

The bacterial flora of some of the Rothamsted plots is shown to be affected not only by the manuring but also apparently by the crops. The protozoan fauna in the soils collected by the British East Greenland Expedition 1935-36 has also been studied.

ENTOMOLOGY

The work on insect population and insect activity has continued; light trap observations went on till February 1937, and were then stopped so as to allow the large numbers of results to be worked out. The number of insects caught during the night was fairly closely related to the minimum temperature; a rise of 4 or 5 degrees F. over the minimum temperature approximately doubled the catch independent of the time of the year or the species of insect. The maximum temperature, however, was much less important.

Work on certain special insects has been continued, notably midges, cabbage aphids and white flies. Much attention has been devoted to insect migration and it has been shown that some of the insects at any rate tended to migrate simultaneously in Europe and in North America. This work on migration will now be put on to a much sounder basis as a grant has been given from the Leverhulme Trustees for the appointment of additional staff.

Increasing attention has been devoted to soil insects and the Department will probably orient its work more and more in this direction for the next few years. Sterilisation of the soil kills all insects but recolonisation soon begins and the population may become three or four times as great as in the untreated soil: it rose as high as 450 millions per acre in one experimental plot.

Especial attention has been paid to the control of wire worms by insecticides and trapping. This work is done in association with the leading groups of heavy chemical manufacturers in the country, Imperial Chemical Industries Dyestuffs Group, and the Association of British Chemical Manufacturers.

Intensive studies on leather jackets are made in association with the Golf Green Research Station at St. Ives.

INSECTICIDES

Considerable developments have occurred during 1936-1937 and this work has now been much extended owing to the action of the Colonial Office and the Ministry of Agriculture in providing additional funds for the examination of British Empire products: Derris and other vegetable insecticides can now be investigated more expediently and more extensively than in the past.

The investigations on pyrethrum have now reached a stage where general conclusions and a full report become possible.

INVESTIGATIONS ON HONEY PRODUCTION

These fall into three groups:

(1) Problems of honey production under healthy conditions;
(2) Bee diseases;
(3) Properties of honey, studied with a view to devising methods of detecting adulteration.

Separate reports are submitted on these subjects but attention should be drawn to the marked interest taken in this work by the honey producers who contributed considerably towards its expense in spite of the circumstance that most of them are only in a small way of business.

THE FARM

As far as possible any records likely to be of practical interest are taken. For some years past measurements have been made of the power consumed in the ordinary farm work of thrashing, grinding, chaff cutting, etc. Electric motors and oil engines have both been used so as to compare units of electricity with gallons of paraffin as sources of power, and to obtain some estimate of the incidental advantages associated with each. This work was done at the instance of the Royal Agricultural Society and paid for out of the grant made by them; it is now completed and the final report is being drawn up.

Experiments are also being commenced on the ploughing up of grassland with a view of studying some of the problems raised during the ploughing up programme of 1917 but left unsolved since.

On the commercial farm the method of rearing calves has been replaced by a much cheaper one which if satisfactory should prove of some value.

INSECT PESTS AT ROTHAMSTED AND WOBURN, 1937

A. C. EVANS

GENERAL

Little trouble has been experienced from insect pests this year. The severe attacks last year on wheat by Wheat Bulb-fly and Wheat Mud-beetle were not repeated.

WHEAT

The Wheat Blossom Midges (*Sitodiplosis mosellana* Géhin and *Contarinia tritici* Kirby) are increasing in number after last year's check.

	Number of Larvae per 500 ears 1936	1937
C. tritici	708	2,556
S. mosellana	2,869	3,409

Mr. A. G. Robertson has carried out a partial survey of the density of infection by the Eelworm (*Heterodera schachtii*) on Broadbalk. This survey is discussed below.

KALE

Flea beetles (*Phyllotreta* spp.) severely damaged the seedlings on Fosters as these were unable to grow away from the attack during the prevailing dry period. The crop in Little Hoos field was not damaged noticeably; seed was sown in June and so germinated when the adult beetles were decreasing in numbers.

BEANS

A severe attack by the Black Bean Aphis (*Aphis rumicis* L.) caused no obvious damage to this crop, the mean yield of the experimental plots being much higher than those of the preceding three years.

WOBURN

No serious pests were noticed. The damage to kale by flea-beetles was less than usual. The carrots were not affected by carrot fly (*Psila rosae* F.) although bad attacks have been reported in the neighbourhood.

EELWORM SURVEY

A partial survey of the density of infection on Broadbalk was carried out by Mr. A. G. Robertson in August. The population of eelworm cysts is not dense enough to cause damage in 1938 but since eelworm can multiply rapidly, attention must, in future, be paid to certain plots in the centre of the field. The eelworms are considered by Mr. W. R. S. Ladell to belong to the oat-strain. From a number of plots, 8 samples, each of 100 grms. of soil (gravel excluded), were examined. The results are given below.

No. of cysts per 800 *grms. of soil in fallow Section II*

Plot No.	2	3	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Cysts.	8	3	1	4	8	13	7	9	33	19	18	5	3	12	7	8	13

At present plot 11 has much the highest population, plots 12 and 13 being next in order of density; the plots on either side of these have an irregular but lower density. Samples were also taken from each of the fallow sections of plots 5, 11, 13 and 19. The results are given below, expressed as number of cysts per 800 grms. of soils.

Plot	5	11	13	19
Fallow Section				
I	0	18	16	2
II	1	33	18	13
III	0	28	16	4
IV	2	42	14	2
V	0	18	0	0

Considerable variation in cyst number is shown along the length of the field but the central plots **11** and **13** are consistently higher than the outer plots **5** and **19**. There is no correlation between the density of infection and the yield either of grain or straw.

FUNGUS AND OTHER DISEASES AT ROTHAMSTED AND WOBURN, 1937

MARY D. GLYNNE

WHEAT

Cercosporella herpotrichoides Fron. first recorded in this country at Rothamsted in **1935**, caused lodging at Rothamsted and in a number of other localities in **1937**. On parts of Broadbalk and on Pastures field where the wheat was very badly laid the disease was found in **80** to **95** per cent. of the culms. It was most abundant and lodging most severe in plots which had received nitrogenous manures and in the most recently fallowed sections of the plots; mineral manures appeared to have comparatively little effect. Wheat grown under different rotational and cultural conditions on other fields at Rothamsted showed much variation in disease incidence; Pennells Piece, adjacent to Broadbalk, was almost free from *Cercosporella* and had a very upright and good crop. These differences suggest possibilities for control, which are under investigation. The disease was slight on wheat grown on lighter soil at Woburn. The fungus was found sporing on stubble in the autumn on Broadbalk and Pastures fields.

White Straw Disease *Gibellina cerealis* Pass. seems likely to be of more academic than practical interest. It has been recorded in Italy since **1886** but does not seem to have been noted elsewhere till it was found at Rothamsted in **1935** on the alternate wheat and fallow experiment on Hoos field. It could not be found in the following year when the adjacent plot was under wheat. In **1937**, a few diseased plants were found in about the same part of the same plot as it had occurred in **1935**. We have no evidence regarding the source of infection. The disease causes considerable damage to individual plants but has hitherto spread so little that it is not at present regarded as of appreciable practical importance.

Wojnowicia graminis (McAlp.) Sacc. and D. Sacc., regarded abroad as a weak secondary parasite, was found in the autumn fruiting on stubble on Broadbalk. There have been two previous field records of it in this country, in Hants.

Mildew (*Erysiphe graminis* DC.), was slight at Rothamsted.

Ergot (*Claviceps purpurea* (Fr.) Tul.): one or two specimens were found on Broadbalk and Pastures fields respectively.

Take-all (*Ophiobolus graminis* Sacc.) was slight to moderate on winter wheat at Rothamsted and Woburn, being distinctly more frequent where wheat was grown after wheat as on Broadbalk or after barley as in the three course cultivation experiment on Long Hoos or after fallow in the alternate wheat and fallow experiment on Hoos field. The disease reappeared on Stackyard field, Woburn in the classic experiment having been absent in 1936 after two years fallow. Its distribution in relation to previous manurial treatment though less in amount was very similar to that observed in the years 1931-33. Spring wheat at Rothamsted showed moderate attack on Great Knott field and on the Exhaustion experiments on Hoos field.

Loose Smut (*Ustilago Tritici* (Pers.) Rostr.) was slight to moderate at Rothamsted and Woburn, there being rather more than usual. In the wheat observation experiment at Woburn it was more frequent on Yeoman than on Square Heads Master.

Yellow Rust (*Puccinia glumarum* (Schm.) Erikss. and Henn.) varied from slight to moderate.

Brown Rust (*Puccinia triticina* Erikss.) varied from slight to plentiful on winter wheat and was plentiful on spring wheat.

Leaf Spot (*Septoria Tritici* Desm.) was slight at Rothamsted in mid-January.

BARLEY

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

Ergot (*Claviceps purpurea* (Fr.) Tul.) was found on Stackyard field, Woburn.

Take-all (*Ophiobolus graminis* Sacc.) was common on Hoos continuous experiment and Fosters commercial crop, both on land which had grown barley the previous two years. It was absent or very slight on barley grown in rotation experiments except on Agdell where the cropping had been : beans or fallow 1934 ; wheat 1935 ; turnips 1936 ; barley 1937. The crop was very poor and the disease plentiful on plots fallowed in 1934, but less severe on those which had grown beans, and had received mineral manure alone or nitrogen, while the plot which had grown beans in 1934 but had no manure was rather badly attacked. The exhausted state of the land is likely to be the chief factor favouring Take-all. The disease was, in general, slight at Woburn, but was moderate on Stackyard classic experiment where barley had been grown the previous year after two years fallow.

Brown Rust (*Puccinia anomala* Rostr.) was moderate to plentiful at Rothamsted.

Leaf Stripe (*Helminthosporium gramineum* Rabenh.) was slight to moderate on several crops at Rothamsted and Woburn, but was apparently absent from others.

Leaf Blotch (*Rhynchosporium Secales* (Oud.) Davis) occurred occasionally at Rothamsted and Woburn.

RYE

Brown Rust (*Puccinia secalina* Grove)
Leaf Blotch (*Rhynchosporium Secalis* (Oud.) Davis) } both diseases were slight at Rothamsted.

GRASSES

Ergot (*Claviceps purpurea* (Fr.) Tul.) was unusually abundant in 1937 and occurred on the grass plots and on various grasses

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growing between fields, notably between Great Knott and Fosters and between Hoos and Fosters and on *Alopecurus agrestis* growing as a weed among sugar beet, mangolds and kale on Long Hoos and Fosters fields. It was found in late summer and autumn plentifully on *Dactylis glomerata*, *Holcus lanatus* and *Alopecurus agrestis*, fairly commonly on *Lolium perenne* and *Agropyrum repens* and occasionally on *Arrhenatherum avenaceum*. Ergot was similarly plentiful on wild grasses in 1932 but had not been observed in the intervening years.

Choke (*Epichloe typhina* (Fr.) Tul.) occurred on *Agrostis* on the grass plots, as usual being most plentiful on the more acid plots where also *Agrostis* was most frequent.

CLOVER

Peronospora Trifoliorum de Bary was rather common on the six course rotation, Long Hoos in the autumn.

Rot (*Sclerotinia Trifoliorium* Erikss.) caused bad patches on the six course rotation experiment, Long Hoos, in the spring and previous autumn. By May the clover was, in general, growing well and the bare patches left by the disease were filled by chickweed.

BROAD BEAN

Chocolate Spot (*Botrytis* spp.) causing two types of lesion, and Rust (*Uroyces Fabae* (Pers.) de Bary) was slight early in the season and moderate by August on Great Knott field.

POTATO

Virus. Leaf Drop Streak (first year symptoms of infection with virus Y) was fairly common at Rothamsted and Woburn on variety Ally.

Leaf Roll was rather common in July on Majestic from Scotch seed at Woburn.

Stem Canker (*Corticium Solani* Bourd and Galz.) was occasionally found on Majestic at Woburn.

MANGOLD

Virus. A little Mosaic disease was found in the autumn at Rothamsted.

SUGAR BEET

Virus. There was a little Mosaic in the autumn at Rothamsted.

LUPIN

Fusarium culmorum attacked about 5 per cent. of the lupin plants on Lansome field, Woburn.

MALTING BARLEY

The fourth Conference on the growing of malting barley was held on November 24th, 1937 on the same lines that proved so successful in the three previous years. Samples were sent in by growers from all the important barley growing districts, accompanied by full agricultural details. These samples were graded by an expert committee of valuers, and were then displayed at the Conference to provide the basis of a discussion of the technical problems of barley growing. The grading distinguished six classes, grades I to III representing pale ale barleys, and grades IV to VI mild ale barleys. The price range between grades was about three shillings per quarter.

This year the value of the lowest grade was three-quarters of the highest, instead of one half as in 1936 or less than one half in 1935.

Yields were low, but the cash returns per acre were probably better than for many years.

The sowing conditions were very poor and continued until late spring; but good growing conditions followed, and harvest weather was good.

The samples reaching the malting standard were 231, divided as follows:

District	I	II	III	IV	V	VI	*Total*	*Mean*
			Grade					
Norfolk	—	3	6	12	10	4	35	4.17
Suffolk	4	12	7	7	4	—	34	2.85
Essex	3	4	7	5	1	1	21	3.00
Kent	2	7	4	1	—	—	14	2.29
Yorks and Lincs ..	—	—	5	9	9	3	26	4.38
E. Midlands	2	4	6	2	4	1	19	3.26
South	1	3	14	17	11	2	48	3.83
West	1	3	4	18	7	1	34	3.88
Total	13	36	53	71	46	12	231	3.59

So far as the samples sent in were representative of their districts, there is a marked effect of locality in the grading results. The Kent barleys were far above the average in quality, those from Suffolk and Essex were distinctly better than average, those from East Midlands slightly better and those from South and West slightly below the average, while those from Norfolk, Yorkshire and Lincolnshire were below it.

The distribution of the grades showed many more samples in the higher grades than in 1936.

1937 *Grade*	I	II	III	IV	V	VI
Percentage	5.6	15.6	22.9	30.7	19.9	5.2

1936 *Grade*	A	B	C	D	E	F
Percentage	2.5	2.9	7.6	19.9	46.6	20.6

The estimates of yield for the various districts were:

Average Yield, bushels per acre

By Districts

Norfolk	35
Suffolk	32
Essex	32
Kent	39
Yorks and Lincs ..	33
E. Midlands	32
West	38
South	32
1937 Mean	34
1937 Min. of Agric. ..	28
1936 Mean	41
1936 Min. of Agric. ..	34

By Grades (All Districts)

	Spring Sown	*Autumn Sown*
I, II, III, ..	36	33
IV ..	34	28 (2 samples)
V ..	34	36 (1 sample)
VI ..	32	—
Mean 1937 ..	34	33
,, 1936 ..	41	39

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The mean yields of the samples were considerably higher than the Ministry of Agriculture estimates. This was not due to optimistic estimates by the senders of the samples, since this year there were 24 measured (threshed) yields which gave an average of 36 bushels per acre, or 2 bushels higher than the average of the estimated yields.

Kent, which produced the best samples also gave the highest mean yield, the West gave nearly as high a yield, while the remainder were very close to the average.

The autumn sown barleys yielded rather less than the spring sown. The best comparison was in grades I to III, where the autumn sown barleys yielded 3 bushels per acre less than the spring sown.

On the other hand, the autumn sown samples were of excellent quality as the following figures show :

	Spring Sown		*Autumn Sown*	
Grade	Number	Per cent.	Number	Per cent.
I, II, III	70	37.0	28	90.3
IV	66	34.9	2	6.5
V	43	22.8	1	3.2
VI	10	5.3	—	—
Total	189	100.0	31	100.0

Practically all the autumn sown samples fell into grades I to III and less than 10 per cent. into grades IV to VI, while of the spring sown samples only 37 per cent. fell into grades I to III and 63 per cent. into grades IV to VI.

The distribution of varieties by districts was similar to that observed in previous years.

So far as the sequence of cropping was concerned there did not appear to be any appreciable difference in the quality of the barleys following corn as compared with those following sugar beet or mangolds. However, the yield of barley following beet or mangolds averaged 3 bushels an acre more than that of barley following grain crops.

Previous Crop

Average Yield in bushels per acre

	Corn		*Beet or Mangolds*		*Kale or Turnips*		*Seeds*	
Grade	No.	Av. yield	No.	Av. yield	No.	Av. yield	No.	Av. yield
I, II, III ..	46	34	29	36	6	37	5	33
IV ..	30	31	19	34	11	37	5	37
V ..	21	33	9	37	4	27	3	31
VI ..	3	30	2	41	3	31	1	24
Total	100	33	59	36	24	34	14	33

The main effect of time of sowing is shown between autumn and spring sowings. An examination of the spring sowing dates shows that very few of the earlier spring sowings fell into the lower grades. However, any effect of time of sowing is rather masked by the general late sowing in 1937, as shown by the comparison of the sowing dates of 1936 and 1937.

Time of Spring Sowing

Grade	Feb.	March 1st-14th	March 15th-28th	March 29th-April 11th	After April 11th
I, II, III	3	6	16	34	9
IV	2	8	9	24	23
V	1	—	5	14	23
VI	—	—	—	5	5
Total 1937 ..	6	14	30	77	60
Per cent. 1937 ..	3.2	7.5	16.0	41.2	32.0
Per cent. 1936 ..	4.9	24.6	45.9	18.9	5.7

The use of manures followed the lines reported in previous years.

Manuring

Grade	No Manure	Artificials only	Organic Manures	Organic + Artificials
I, II, III	7	57	19	15
IV	8	33	17	11
V	3	22	10	9
VI	—	3	5	2
Total	18	115	51	37
Per cent. 1937 ..	8	52	23	17
Per cent. 1936 ..	14	44	30	12

Of the 152 samples for which artificials were used, just one third of them used the newer high analysis compound fertilisers.

There seems to be little indication from these figures that the use of no manure resulted in better quality. When artificials were used some form of nitrogen was practically always included, even when artificials were applied after sheeping or ploughing in tops. The average dressing of nitrogen in artificial form was just under 20 lb. N per acre or slightly less than the equivalent of 1 cwt. sulphate of ammonia.

In 1937, out of over 200 samples, only 23 cases of very slightly lodged samples were reported, as compared with 21 per cent. seriously lodged in 1936.

CHANGES IN STAFF

The Station has unfortunately lost a number of valuable members of staff during the year (see page 10) and serious consideration should be given to the avoidance of too great a rate of change. A certain movement through the Institution is desirable but when changes occur too frequently a serious loss of time and money becomes inevitable.

FARM REPORT, 1937

Weather

The outstanding weather feature of the year 1936-37 was the extremely wet winter and spring. The rainfall for the six months November to April amounted to 21.867 inches compared with the 84 year average of 13.553, and for the three months January to March was over twice the normal. The total for the year amounted to 35.859 inches compared with the 84 year average of 28.625 inches. The summer months on the whole were drier than the average. The sunshine figures were far below the average and eleven months of the twelve gave figures below the average, although mean temperatures were slightly better than average.

Weather and Crops

The weather conditions very seriously affected the work of the farm, for during the first three months of 1937 no land work could be done. Sowing of spring corn did not commence until the end of March, and even then conditions were not really suitable. However, most of the corn was sown by mid-April. No harrowing or rolling operations were done to wheat or barley as by the time the land was fit for these operations the crop was too forward. Towards the end of April and early May there was a dry spell with strong winds which dried and hardened the surface soil and made it difficult to get suitable seed beds for root crops. Only surface cultivations could be given as deeper work brought large lumps of sodden unweathered soil to the surface. Potatoes went in under bad conditions. The late ploughing and the absence of frosts during the winter made it difficult to get even a surface tilth. When bouting took place the plough cut through lumps of cold and wet soil and the sets thus had a poor start. However, subsequent growth was better than was expected and no blight occurred. The summer was mainly dry and although this was very suitable for hay and harvest work, the root crops grew very slowly. Wheat crops ripened fairly evenly but barley very unevenly and much had to be cut before the whole field was properly ripe. The favourable harvest conditions enabled many of the non-experimental crops to be threshed in the field, and all non-experimental wheat and oats were so treated. Hoosfield, Agdell and the Half Acre wheat were also threshed without stacking.

Classical Experiments

Broadbalk was ploughed only once for the 1937 crop as we wished to avoid the possible delay in sowing that would occur if the second ploughing was delayed by adverse weather conditions. The wheat grew well throughout the year and no apparent damage was done by the wheat bulb fly. Most of the plots were badly laid before harvest, the only exceptions being the unmanured and rapecake plots. The crop on the plot receiving minerals only was pulled to the ground by vetchlings. The plots were almost free of poppies and those that grew in the paths or edges of the plots were cut or hand-pulled. Broadbalk was the first crop to ripen and although bird damage occurred before cutting and in the stook the damage was far less than in the past few years. The field took longer than usual to harvest owing to the laid condition of most of the plots.

The wheat plant in the Hoosfield Half Acre was thin and the ears were very small, but again there was no attack by bulb fly. Although this area was sown with the same variety as Broadbalk at the same time the wheat was very slow in ripening and was one of the last pieces of corn to be cut.

Hoosfield barley plots were sown very late and only a thin plant came through. Growth during the summer was very slow and the crop appeared very stunted. At harvest time the field presented a sorry picture for many of the ears had not completely emerged from the sheaths and many ears contained little or no grain. The dunged plot appeared to be easily the best plot on the field. Wild oats and black medick were prevalent on most of the plots. The plots ripened very unevenly and although cutting was delayed until early September all the plots were not completely ripe.

Agdell barley presented much the same appearance. Growth stopped early in summer and the crop turned yellowish. At harvest time the crop was not more than nine inches high and the undersown clover was nearly as tall as the barley. All the plots presented much the same appearance except that self-sown black medick took the place of the clover on the half to be fallowed in 1938. However there was noticeably less black medick on the fallow side of the plot receiving complete manures.

Barnfield was ploughed rather earlier than usual but the absence of frosts made it rather difficult to work the land down to a good seedbed. The cultivator could not be used as it brought unweathered soil to the surface, and so only surface cultivations could be made. Quite a good seedbed was finally obtained and drilling took place on May 8th. The seed germinated well but weeds grew fast and much hand and horse hoeing was necessary. Singling was done rather late and this probably had some effect on the yields, which were rather low.

The exhaustion land in Hoosfield was cropped with spring-sown Little Joss wheat after fallow in 1936. Growth in early summer was exceptionally slow despite good sowing conditions. Fairly rapid growth took place in July, but the crop was rather poor and patchy, and the ears were small. The crop was still quite green in August and the ground was carpeted with black medick. The crop was harvested according to the old potato plots in late September, but much bird damage was done both before cutting and while the crop was in the stooks.

Modern Long-Term Experiments

Four-Course Rotation. The wheat crop looked poor throughout the summer, with short straw and small thin ears. The ryegrass and barley were average crops, but the latter ripened unevenly. The potato land was rough but as the season was well advanced the sets were planted. Growth during the season was slow and yields were low.

Six-Course Rotation. The wheat crop looked well throughout the summer. The straw was long and the ears large and well filled. Unfortunately several plots were laid before harvest. The barley also looked well, being a clean, even crop with well-filled ears. This was the only piece of barley on the farm which ripened evenly and early. The rye grew well and all plots were standing at harvest. The crop ripened later than usual. The clover plant was thick and even but no great growth was made. The ley was ploughed in immediately after the removal of the hay to give the area a bastard fallow. The clover undersown in the barley took well. Sugar beet and potatoes went into a rather coarse tilth and the effect of the late sowing and poor start lasted until the crops were harvested.

Three-Course Rotation (*Straw and Green Manure*). The barley showed big plot differences quite early in the season. The crop ripened unevenly, the plots receiving their manures in 1937 ripening earlier than those which were manured in 1936. Two plots were badly damaged by rooks. Potatoes were set under poor conditions and growth was slow, very little top being made. Rooks started to damage the tubers and the final earthing-up had to be done early to reduce this damage. There was a good plant of sugar beet but growth was slow throughout the summer.

Three-Course Rotation (*Cultivation*). The wheat crop was very disappointing. The plant was thin and short in the straw, and the ground underneath became very weedy. All the ploughed plots were far better than either the tine or rotary cultivated plots, and were far less weedy. There was no apparent difference between the tine cultivated and the rotary cultivated plots. The barley, although rather disappointing early in the season, developed into an even well-standing crop with no obvious plot differences. The ears were well filled and the grain of good size. The mangolds were sown on a rather coarse tilth. However a good even plant was established which grew well throughout the season.

Annual Experiments

Leys in preparation for wheat. This experiment which was designed to test the effect of different leys and green manures on the following wheat crop proved very successful and interesting. The ley plots grew well and yielded a good first cut, and the growth of the following mustard or vetches demonstrated clearly which ley crop they were following. The green crops after the fallow and clover grew far better than after the clover and grass mixtures, but the crops after rye-grass alone grew very small.

Kale. The experiment using kale to test the immediate and residual effects of different forms of organic manure fared badly. However this was not surprising as it was the second kale crop following two successive crops of brussels sprouts. The plant germinated well, but was attacked by flea beetle which made it rather gappy. Early growth was quite good although the ground beneath was rather weedy. Later, however, the plant stopped growing and although certain plots showed up as more green than others, the whole area turned a yellowish colour, and in autumn

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assumed a purplish tinge. Many of the lower leaves of the plants turned brown, withered and dropped off, and the whole area had the appearance of suffering from a deficiency disease.

Sugar Beet and Mangolds. The sowing of both these experiments was delayed until mid-May, and suitable seedbeds were only obtained with difficulty. Good growth was made during the summer although the mangolds were rather patchy. Both experiments were attacked by bean aphis early in July and were sprayed with nicotine and soft soap before much damage was done. The sugar beet yielded well and the mangolds produced an average crop.

Potatoes. Ploughing for this experiment was not finished until February on account of the weather, and planting was delayed until the end of May. The potatoes came through quite well and made good growth during the summer. Plot differences could easily be seen by the size and colour of the haulms.

Beans. The seed was ploughed in at the end of November and grew well throughout the summer. Growth was strong and upright, and the crop flowered well. Unfortunately an attack by bean aphis early in July did great damage and restricted pod formation. The crop was too tall to spray and the attack had to run its course.

Non-experimental Cropping, 1936-7.

The ploughing for kale in Little Hoos field was done very late, and owing to the flooded condition of the dung yards and the sodden state of the ground it was impossible to apply dung to the field. A good seedbed was eventually obtained but growth was slow in spite of the application of five cwt. per acre of nitrochalk.

The wheat in Pastures field looked well early in the season but turned yellowish during the summer. The ears were rather small and most of the field was badly laid before harvest. Yields were low.

Great Harpenden field was sown with Star Spring Oats in the middle of April and despite the late sowing no frit fly attack occurred. The crop ripened rather late but yields were average.

Foster's field was planned to be sown with spring beans, but sowing was delayed by weather conditions and pressure of experimental work. As sowing had not been done by the end of March the cropping was altered to barley in spite of the fact that this would be the third successive barley crop. The plant was rather thin, but the crop was even and the ears were of good size.

Harwood's Piece was sown late with Rivett wheat, but much of the seed rotted in the ground owing to the wet conditions. The plant which came through was very thin and weak, and so the crop was ploughed in during early summer and the field was fallowed for the rest of the year.

Considerable difficulty has been experienced on our heavy soil in past years in working the land down to a suitable barley seedbed after folded kale, especially when some of the kale is reserved for spring use. Furthermore, the crop has nearly always been lodged with consequent loss of time and crop at harvest. This year

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after folded kale, Long Hoos was sown with Abed Kenia barley a Danish variety which as it need not be sown until much later than usual, gives more time in which to utilise the kale and prepare the seedbed. The straw is also very strong. The seed was not sown until May 10, but the crop grew well and ripened soon after the earlier sown barleys. The straw was short and stood well, and the crop yielded 17 cwt. of grain per acre, which was sold at 60/- per quarter.

High Field Grazing Experiment

This experiment is planned to assess the residual manurial value of feeding stuffs fed to stock on grassland, and the arrangement is described on page 25. In the spring of 1937 the field was divided into three blocks each of three plots by steel post and wire fencing. Water was laid on to each plot, the ¾-inch pipe being drawn through the ground behind a mole plough drawn by a traction engine. This method proved far cheaper and quicker than the trenching method and has proved quite efficient. After double chain harrowing a random half of each plot was dressed with basic slag at 10 cwt. per acre. A central weighing machine was installed with suitable collecting pens.

The season 1937 was used to develop the technique and to conduct a uniformity trial on all plots. Grazing did not commence until the end of May as the fencing was not completed before, and at first cattle alone were used. The grass was topped early in July and sheep were added to each plot immediately after this operation. The stock was weighed at fortnightly intervals throughout the grazing period, the water troughs being covered the evening before the day on which the weighing was done. The mixed grazing continued until the end of September when the sheep were removed. Grazing by cattle continued well into November and the field was then left unstocked through the winter. The stock used in 1937 were Aberdeen Angus × Shorthorn heifers and Half-bred ewes and hoggs.

Estate Work.

About fifty trees were felled on the farm during November, 1936, but only badly mis-shapen, dead or dying trees or those that interfered with cultural operations were felled. The removal of these will help to reduce bird damage to crops at harvest time, will destroy natural harbourage for weeds and vermin, and will enable full use to be made of the arable fields.

Grassland

The hay crops were quite good and none were laid before cutting. All the grass was cut by the tractor mower and swept to the stack by a car sweep so that horses could be freed for other work. The hay was made under good conditions and yielded good average crops. The aftermath grew well and provided excellent keep for lambs after weaning. All the grass fields which were not cut for hay were topped, and throughout the season there was sufficient short palatable grass for the stock.

Livestock

Horses. Two young Suffolk horses were purchased in the spring to replace two of the old horses. The old team was kept for a time after the purchase of the Suffolks to enable us to make up the arrears of spring work.

Cattle. The cattle policy, started in 1929, of keeping Dairy Shorthorn cows to rear several calves each during their lactation did not prove successful. The high labour and feeding-stuff costs, the difficulty in obtaining suitable calves at the right time, and the time taken by the poorer calves to grow to beef were the main causes of failure. This policy was abandoned in 1934. Between 1934 and 1937 the cattle reared in this way were sold and two lots of Irish cattle were fattened off.

The policy now being adopted is to make hardy cows of the beef type to a similar type of bull, and allow them to rear one calf each during the summer. The cows out-winter without receiving concentrates and calve down out of doors in the spring. The calves run out at pasture with their mothers during the summer months and are weaned into sheds or yards in the autumn. The calves can then either be sold for box fattening, as stores, or be kept on for fattening, whichever promises to pay best. This policy makes us independent of many of the price fluctuations, and reduces costs to a minimum. Fifteen Kerry heifers were purchased and bulled to calve in the spring of 1938, and Blue-Grey (white Shorthorn × Galloway) heifers will be purchased and bulled to calve in the spring of 1939.

Sheep. The investigational work done between 1931 and 1935 is now being examined statistically and a report of the results of this work will be published in the 1938 Station Report. No further investigations will be undertaken until the results of the previous work is known. In the meantime the flock, which had become very mixed has been severely culled and replacements have been made by Scotch Halfbred gimmers. It is now run as a commercial flock for the production of fat lambs.

Two Hampshire tups were used for the 1937 lamb crop and the lambs produced fattened rapidly to good stocky lambs well suited to local markets. For the 1938 lamb crop Hampshire tups only will be used.

The 1937 lamb crop averaged 125 per cent. Conditions during lambing were bad owing to the incessant rain, and this combined with the lack of sun gave the lambs a poor start. The wet conditions gave rise to a lot of udder trouble and sore teats in the ewes.

Fifty Suffolk ewes were purchased in the autumn of 1937 as the foundation flock for breeding pure bred tegs for the High Field Grazing experiment.

Pigs. A large number of deaths of small pigs occurred during the winter and early spring, and the primary cause of death was pneumonia, brought about by damp and draughty beds, and unsuitable buildings generally. Throughout the summer the pigs did quite well. Other buildings are now being converted into farrowing pens to minimise losses of small pigs.

No further experiments will be carried out in the individual feeding pens as although they served their purpose in developing the individual feeding method of experimentation, they are quite unsuited to present-day requirements.

Although no bacon contract was in operation, pigs were sent to the bacon factory, and the following table shows the percentage grading returns for 1937 :

Total delivered	Class A	Class B	Class C	Class D	Under-weight
104	71	22	5	—	2

Show Successes

At the Hertfordshire and Bedfordshire Bacon Competitions we entered one pair of pigs and secured the first prize in the class, and the reserve championship for the best pigs in all classes. At the Redbourn Ploughing Match C. Mepham secured the first prize for turnout and L. Stokes third prize for ploughing.

Buildings

The new Adco building and feeding boxes were completed during the year. These will enable the Adco for the experiments to be made and stored under suitable conditions, and dung for experiments to be made and stored under known conditions.

The pair of new cottages were completed and provide much needed accommodation for stockmen who must live on the farm.

A new shed has also been erected by farm labour to house ploughs and hoes, etc.

Staff

J. B. Matthews spent a year on the farm as a voluntary worker.

Implements

We now have at the farm a collection of 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.
Bamfords, Ltd.	Hay machinery.
E. H. Bentall & Co., Ltd.	Cake breaker ; root grapper.
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.
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.	Drill, manure distributor.
A. Jack & Sons, Ltd.	Root drill and hoe.
R. A. Lister & Co., Ltd.	Oil engine, sheep shearing machine, self-cleaning grass harrows.
Miller Wheels, Ltd.	Tractor wheels.
G. Monro, Ltd.	Motor hoe.
Parmiter & Sons, Ltd.	Rake and harrows.
Ransomes, Sims & Jefferies, Ltd.	Ploughs, cultivators, grass rejuvenator.
Ruston, Hornsby, Ltd.	Grain drill, binder.
J. Wallace & Sons, Ltd.	Manure sower, potato planter.
J. Wilder.	Pitch-pole harrows.
W. A. Wood & Co., Ltd.	Mower, spring tine harrows.
Oxford Institute of Agricultural Engineering.	Automower.
The Harvest Saver & Implement Co.	Prime Electrical Fence.

METEOROLOGICAL OBSERVATIONS

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

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

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

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

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

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

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

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

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

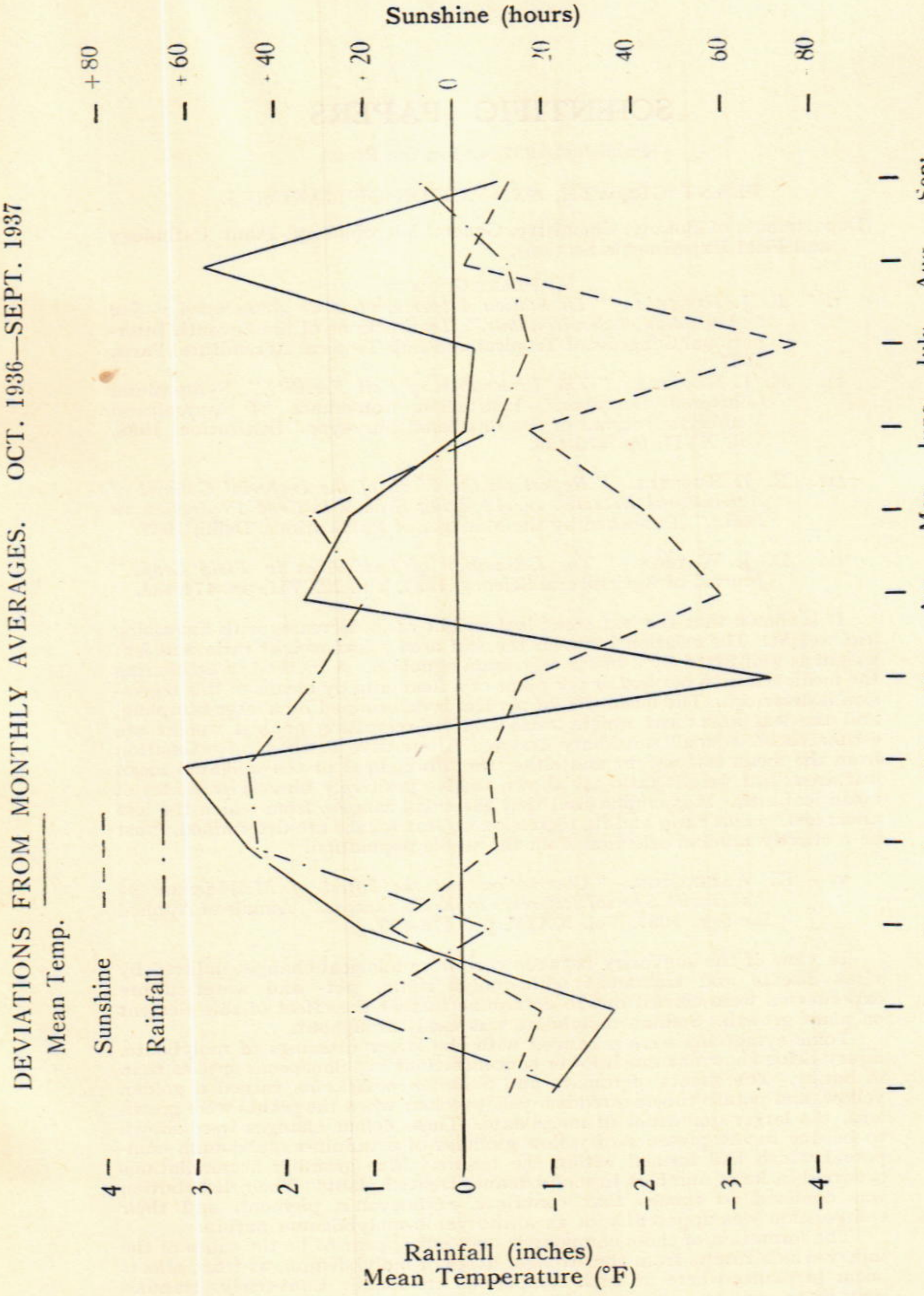
Rainfall and Drainage.—The rain falling on one-thousandth of an acre is collected in the big gauge erected by Lawes in 1871. Samples of the water are analysed in order to ascertain its nutrient value.

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 gauge is used in conjunction with these.

*Discontinued October, 1935.

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

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


DEVIATIONS FROM MONTHLY AVERAGES. OCT. 1936—SEPT. 1937
Mean Temp.
Sunshine
Rainfall
Sunshine (hours)
+80
+60
+40
+20
0
20
40
60
80
4
3
2
1
0
-1
-2
-3
-4
Oct.
Nov.
Dec.
Jan.
Feb.
Mar.
Apr.
May
June
July
Aug.
Sept.
Rainfall (inches)
Mean Temperature (°F)

SCIENTIFIC PAPERS

(Published 1937, and in the Press)

PLANT GROWTH, AND ACTION OF MANURES.

(Departments of Botany, Chemistry, General Microbiology, Plant Pathology and Field Experiments Section).

(a) PLANT GROWTH

I. E. J. RUSSELL. "*La Station Experimentale de Rothamsted ; Son Organisation et Ses Resultats.*" Transactions of the Seventh International Congress of Tropical and Sub-Tropical Agriculture, Paris, 1937.

II. E. J. RUSSELL. "*The Restoration of Soil Fertility.*" Symposium, Chartered Surveyors' Institution Conference of Agricultural Members. Journal of the Chartered Surveyors' Institution, 1938, Vol. XVII, pp. 479-486.

III. E. J. RUSSELL. "*Report on the Work of the Imperial Council of Agricultural Research in Applying Science to Crop Production in India.*" Published by the Manager of Publications, Delhi, 1937.

IV. D. J. WATSON. "*The Estimation of Leaf Area in Field Crops.*" Journal of Agricultural Science, 1937, Vol. XXVII, pp. 474-483.

It is shown that the leaf area : leaf weight ratio decreases with increasing leaf weight. The relation between the leaf area : leaf weight ratio and leaf weight is well fitted by a linear regression equation. A method of estimating the mean leaf area per leaf or per plant of a field crop by means of this regression is described. The mean weight per leaf is determined by a large sampling, and the leaf area : leaf weight ratio and its regression on leaf weight are estimated on a small subsidiary sample. Alternative methods of estimation from the mean leaf weight and either the unweighted or the weighted mean leaf area : leaf weight ratio are shown to give positively biassed estimates of mean leaf area. It is emphasized that the small sample, from which the leaf area : leaf weight ratio and its regression on leaf weight are determined, must be a strictly random selection from the whole population.

V. K. WARINGTON. "*Observations on the Effect of Molybdenum on Plants with Special Reference to the Solanaceae.*" Annals of Applied Biology, 1937, Vol. XXIV, pp. 475-493.

In view of the similarity between certain cytological changes induced by virus disease and treatment with molybdenum, pot- and water-culture experiments were carried out to determine further the effect of this element on plant growth. Sodium molybdate was used throughout.

Toxic symptoms were produced with the larger dressings of molybdate, injury being shown at much lower concentrations in solanaceous species than in barley. The shoots of tomato and *Solanum nodiflorum* turned a golden yellow, and potato tubers a reddish yellow colour when the plants were grown with the larger quantities of molybdate. These colour changes were shown to be due to the presence of yellow globules of a tannin-molybdenum compound which had formed within the tissues. Blue granular accumulations occurred in large numbers in molybdenum-treated plants. Their distribution was confined to tissues that contained anthocyanin pigment, and their composition was apparently of an anthocyanin-molybdenum nature.

The formation of these compounds does not appear to be the cause of the injury which results from the stronger doses of molybdenum, as toxic effects occur in plants where no such compounds are found. Conversely, granules may be present to a quite considerable extent in apparently healthy plants.

https://doi.org/10.23637/ERADOC-1-69

Molybdenum, therefore, evidently plays a part in the cytological and morphological behaviour of the plant, although its precise function remains to be determined.

VI. W. E. Brenchley and D. J. Watson. "*The Influence of Boron on the Second Year's Growth of Sugar Beet Affected with Heart-Rot.*" Annals of Applied Biology, 1937, Vol. XXIV, pp. 494-503.

Heart-rot of sugar beet occurred on experimental plots at Rothamsted during 1935, the severity of the attack decreasing steadily with later sowing, but the effects of spacing of the rows and of treatment with sulphate of ammonia were not significant. Where the number of affected plants per row was high, a higher proportion of affected plants showed severe symptoms.

Unaffected sugar beets and others showing slight and severe symptoms of heart-rot were transplanted to sand cultures and treated with light and heavy dressings of boric acid or with none In the absence of boric acid the characteristic signs of boron deficiency appeared in the shoots, the apices of the stems and the flower buds blackening and dying. This occurred even when no symptoms were present before transplanting. In the presence of boric acid all plants produced healthy shoots, with no deficiency symptoms. Where heart-rot was originally present and the main axis killed, a number of healthy, lateral shoots was produced.

The proportion of plants failing to survive transplanting was greatest with the heavy dose of boric acid, with which one-half of the plants died. This suggests a possible toxic action of the heavy dose which did not come into play if the plants were constitutionally able to withstand the initial poisoning and start away into growth. The later addition of boron did not improve the condition of the roots of affected plants, as irremediable damage had been done before transplanting.

From the point of view of seed production, small amounts of boron compounds may thus enable affected roots to produce healthy shoots in the second year which will set seed.

VII. A. Nowotnówna (Nowotny). "*An Investigation of Nitrogen Uptake in Mixed Crops not Receiving Nitrogenous Manure.*" Journal of Agricultural Science, 1937, Vol. XXVII, pp. 503-510.

Experiments on the nitrogen uptake of mixed crops not receiving nitrogenous manure were carried out at Pulawy, Poland, and at Rothamsted, with rye grass. The total yield, the nitrogen percentage and the total yield of nitrogen were much increased when peas, clover or serradella were grown in association, peas giving the highest, and serradella the lowest, amount of assimilated nitrogen.

With barley, peas were the only crop which produced a beneficial effect, red clover and lucerne having no influence. This was probably due to the fact that the period of most vigorous fixation of nitrogen by clover and lucerne nodule bacteria almost coincided with the period of ripening of barley, and at this stage of growth barley was unable to utilize the available nitrogenous compounds. Also, barley made less use than rye grass of the nitrogen provided by peas grown in association.

An extensive root interpenetration in the clover-rye grass pots was noted. There was little or no root interpenetration in the other series of experiments with barley.

VIII. J. Caldwell and J. Meiklejohn. "*Observations on the Oxygen Uptake of Isolated Plant Tissue. I. The Effect of Phosphate and of added Carbohydrate.*" Annals of Botany, 1937, New Series, Vol. I, pp. 477-486.

The oxygen uptake of thin slices of tomato stem tissue was measured in Barcroft respirometers, and found to be maintained at a constant rate over a six-hour period. The highest values for oxygen uptake were observed in presence of M/20 potassium dihydrogen phosphate ; measurements in distilled water gave slightly lower values, and stronger solutions of phosphate produced a marked depression of oxygen uptake. Tissue from very young plants, in the fifth leaf stage, showed a lower level of oxygen uptake than tissue from slightly older plants, up to the twelfth leaf stage. A low level of oxygen uptake was also observed in tissue from old plants that had flowered.

The small oxygen uptake of tissue from very young plants was markedly raised by the addition of glucose or fructose, but no such rise was observed on adding sugar to tissue from very old plants. It is concluded that the oxygen uptake is limited in old plants by the activity of the respiratory enzyme system, and in very young plants by the amount of available respiratory substrate.

IX. J. CALDWELL and J. MEIKLEJOHN. "*Observations on the Oxygen Uptake of Isolated Plant Tissue. II. The Effect of Inhibitors.*" Annals of Botany, 1937, New Series, Vol. I, pp. 487-498.

Substances known to inhibit enzyme action were added to slices of tomato stem tissue, and their effect on the oxygen uptake of the tissue was measured. All the substances showed an inhibiting action which increased with their concentration. Concentrations lower than those which inhibited oxygen uptake were found to have no stimulating effect. Cyanide (M/300) produced a reversible inhibition of about 85 per cent. of the total oxygen uptake; no greater inhibition was produced by M/30 cyanide than by M/300. Sodium fluoride and iodoacetic acid had an irreversible inhibiting action, and sodium azide a reversible one stronger in acid than in alkaline solution. Malachite green was effective in very small doses, but the urethanes only in high ones. Amyl alcohol was ineffective at 1/3,000, but produced almost complete inhibition at 1/30.

(*b*) ACTION OF MANURES

X. H. L. RICHARDSON. "*The Nitrogen Cycle in Grassland Soils: with Especial Reference to the Rothamsted Park Grass Experiment.*" Journal of Agricultural Science, 1938, Vol. XXVIII, pp.73-121.

A three years' examination of Park Grass soils and shorter studies of other grassland soils showed that fresh soil always contained more ammonia than nitrate. Both levels were low and sufficiently constant to suggest equilibrium conditions in the nitrogen cycle. "Mineralizable" nitrogen, produced by incubating the fresh soils under standard conditions, showed a seasonal rhythm the opposite of the annual temperature rhythm. This was related to the addition and decay of organic residues in the soil. An extremely acid soil produced as much mineralizable nitrogen on incubation as more normal plots. Soils with pH values below 6.0 produced chiefly ammonia while the less acid soils produced chiefly nitrate on incubation.

Nitrogen added in the field as sulphate of ammonia or nitrate of soda disappeared rapidly, one-half being removed in a few days in late spring or in a week or two in winter or early spring. The rapid disappearance of ammonia, even on plots in which nitrification was poor or lacking, suggested that it was taken up directly by the herbage. When the herbage was removed, added ammonia remained in the soil for several weeks.

Under Rothamsted soils laid down to grass from arable, about twenty-five years are required for the total nitrogen content to reach half that of very old grassland.

The number of worm casts was greatest on plots with organic manures, and limed plots usually had more than unlimed. Worms were absent from the extremely acid matted plot and the formation of mat appeared to depend on the effect of acidity on the worms rather than on the microbiological decomposition of the organic matter.

XI. W. E. BRENCHLEY. "*Correlation of Manuring and Botanical Composition of Continuous Hay Crops.*" Report of the Fourth International Grassland Congress, Aberystwyth, 1937, pp. 441-445.

The botanical composition of herbage varies widely in different seasons. Moreover, seasonal and manurial effects need careful discrimination.

Repeated treatment with the same fertilizer affects the botanical composition and the relative proportions of species present, the latter effect often being the more striking. On heavy clay loam at Rothamsted, although the qualitative composition is not seriously altered by mineral manures, some species are much encouraged and others are considerably reduced, the relative variation being influenced by season. The addition of nitrogen eliminates many species, and with heavy dressings a few grasses develop strongly at the expense of the rest. Nitrate of soda and ammonium sulphate do not encourage the same association of species on account of the difference in soil reaction. The acidity induced by heavy doses of ammonium sulphate much favours *Holcus lanatus*, but the addition of lime brings *Alopecurus pratensis* and *Arrhenatherum avenaceum* into predominance, leguminous and other plants being drastically reduced. With the neutral reaction induced by sodium nitrate *Alopecurus* and *Arrhenatherum* flourish without lime, shade being here more effective than liming in changing the proportion of species.

With organic fertilizers the yield may be reduced by heavy dressings of lime without very marked alterations in herbage composition. The response to lime is rapid, as the species affected usually show a variation in their relative proportion at the first cutting, although in some conditions the change may be delayed.

Certain species afford some indication of soil and manurial conditions. *Taraxacum vulgare* is prolific on well manured soils with a tendency to alkalinity; *Scabiosa arvensis* flourishes where potash is deficient and no nitrogen is applied; *Rumex acetosa* is possibly associated with scarcity of phosphate on soil which is otherwise well manured; while Leguminosae may form a third of the herbage where minerals without nitrogen are given.

STATISTICAL METHODS AND RESULTS

(Department of Statistics)

(*a*) Design of Experiments

XII. F. Yates. "*The Gain in Efficiency Resulting from the Use of Balanced Designs.*" Supplement to the Journal of the Royal Statistical Society, **1938**, Vol. V, pp. **70-74**.

The comparative efficiency of a balanced design, which was actually used in a nutritional experiment on human beings, and other alternative and simpler designs, is assessed. It is shown that the balanced design is considerably more efficient than the others.

XIII. W. G. Cochran. "*Note on J. B. S. Haldane's paper 'The Exact Value of the Moments of the Distribution of χ^2.'*" Biometrica, **1938**, Vol. XXIX, p. **407**.

A discrepancy noted by Haldane between his and the writer's values for the mean and variance of χ^2 in a $2 \times$ n-fold contingency table with known expectations is shown to be entirely due to a difference in the definition of χ^2.

(*b*) Analysis of Data

XIV. F. Yates and W. G. Cochran. "*The Analysis of Groups of Experiments.*" Journal of Agricultural Science, **1938**, Vol. XXVIII, in the press.

When a set of experiments involving the same or similar treatments is carried out at a number of places, or in a number of years, the results usually require comprehensive examination and summary. In general, each set of results must be considered on its merits, and it is not possible to lay down rules of procedure that will be applicable in all cases, but there are certain preliminary steps in the analysis which can be dealt with in general terms. These are discussed in the present paper and illustrated by actual examples. It is pointed out that the ordinary analysis of variance procedure suitable for dealing with the results of a single experiment may require modification, owing to lack of equality in the errors of the different experiments, and owing to non-homogeneity of the components of the interaction of treatments with places and times.

XV. W. G. Cochran. "*Some Difficulties in the Statistical Analysis of Replicated Experiments.*" Empire Journal of Experimental Agriculture, **1938**, Vol. VI, pp. **157-175**.

The analysis of variance is now widely applied in interpreting the results of replicated experiments. Sometimes, however, a combined analysis on the original data has little meaning and gives misleading results, because the treatments have different variances. A numerical example is given to illustrate such a case.

These cases may be divided into two groups. (1) With yield-data, or whole-number counts of over 100 per plot, they occur very rarely, but may do so if some treatment differences are of the order of several hundred per cent., or if there is a partial failure of certain treatments or plots. The analysis is best carried out by omitting some treatments or plots. (2) With small whole numbers or percentages, the distributions tend to follow the Poisson and binomial types, respectively, and there is a known relation between the variance and the mean. Data of this type should be transformed before an analysis to a scale on which the variances are equal.

Three transformations have proved particularly useful in practice. (*a*) The square root, for whole numbers per plot between 10 and 100. If the majority of the plot-yields are under 10, one-half should be added to each plot-yield before taking the square root. (*b*) The inverse sine, i.e. the angle whose sine is the square root of the fraction, for percentages and fractions based on the ratio of small numbers. Percentages can, however, often be dealt with either by square roots, for small percentages, or by a direct analysis, for percentages from 30 to 70. (*c*) The logarithm, for distributions in which the standard error is proportional to the mean.

Numerical examples are worked, illustrating the use of each of these transformations and the way in which to present the results of the experiment.

A brief discussion is given of the analysis when the results consist of the number of plants in each of a number of grades (e.g., healthy, slightly diseased, severely diseased).

With factorial experiments in which the main effects produce large differences, the experimenter must consider what is the most natural definition of the independence of two factors, since the conventional test of interactions in either the original or the transformed scale may have little relation to this. A numerical example is given illustrating this point.

XVI. W. G. COCHRAN. "*Recent Work on the Analysis of Variance.*" Journal of the Royal Statistical Society, 1938, Vol. CI, pp. 434-449.

This review covers the period 1934-7. The principal topics summarised are experimental design, the discriminant function and its uses, the analysis of covariance and the use of transformations with non-normal data.

XVII. H. FAIRFIELD SMITH. "*An Empirical Law Describing Heterogeneity in the Yields of Agricultural Crops.*" Journal of Agricultural Science, 1938, Vol. XXVIII, pp. 1-23.

The object of the paper was to investigate the relationship between the plot size and the variance of the plot yields. Using data from a blank experiment with wheat it was found that the regression of the logarithms of the variances for plots of different areas on the logarithms of their areas was approximately linear. A graphical review of variances, etc., reported in the literature for thirty-nine other blank experiments indicates that the results of most such experiments conform to the same law.

It is shown that the above law can be generalised (so as to be applicable to any size of field) by applying a certain adjustment to the regression coefficient b', so as to give a modified coefficient b applicable to an "infinite" field.

From this generalized relationship there has been deduced an expression to indicate average relative efficiencies to be expected for randomized block experiments with varying numbers of plots per block in a field for which the coefficient b is known.

A formula, which may be used to estimate the most efficient size of plot for any given experiment, has also been deduced. The cost of using plots of other than the most efficient size is indicated graphically.

(*c*) SAMPLING

XVIII. W. G. COCHRAN. "*Crop Estimation and its Relation to Agricultural Meteorology.*" Supplement to the Journal of the Royal Statistical Society, 1938, Vol. V, pp. 1-25.

This is one of three papers read to the Industrial and Agricultural Section of the Royal Statistical Society, with discussion. The first paper, by Dr. Irwin, describes critically the official methods of crop estimation in the United Kingdom, the United States and India and outlines the early work of the crop-weather scheme of the Agricultural Meteorological Committee. In the second paper, by Mr. Cochran, the use in crop forecasting of the correlation of yields with weather factors and with previous measurements on the crop is discussed. A prediction formula is presented for wheat, based on the results of the wheat sampling observations under the crop weather scheme. This formula is as yet unsatisfactory in forecasting variations in yield from year to year, but may be improved by the inclusion of weather effects when sufficient data become available. In general, however, much research is still needed on the possibility of crop forecasting by this method.

The estimation of crop yields at harvest by taking small samples from a number of fields is considered and the results obtained from an extension to commercial crops of the wheat sampling scheme are presented. The chief difficulties here appear to lie in the selection of fields to be sampled and in a positive bias which persists in the sampling yields as compared with the harvested yields of whole fields. The use of a fixed panel of forms for each crop is recommended as the most practicable method of organising the work.

The third paper, by Dr. Wishart, sums up several points in the first two papers and describes the system of crop estimation in China.

THE SOIL

(Departments of Chemistry, Fermentation, and Physics)

(*a*) Cultivation

XIX. E. W. Russell and B. A. Keen. "*Studies in Soil Cultivation. VII. The Effect of Cultivation on Crop Yield.*" Journal of Agricultural Science, 1938, Vol. XXVIII, pp. 212-233.

The yields of wheat, barley and mangolds were not appreciably affected whether the seed beds were prepared by ploughing and harrowing, by using the grubber (or cultivator) and harrowing, or by using the Rototiller, provided that the grubber and Rototiller were used for one year only. If used for several years in succession deterioration of yield sometimes sets in, possibly due to the increased weediness of the non-ploughed plots.

There was no advantage in ploughing deeper than 4 in. but it is advantageous to use the grubber or Rototiller deeper.

For spring-sown crops, cross-ploughing, subsoiling, or heavy rolling of the seed bed were without effect on the yield.

Spring rolling and harrowing improved the yield of winter wheat but had little effect on the yield of straw. Rolling alone produced a slightly increased yield of grain. The straw yield was increased by rolling but depressed by harrowing.

There was strong evidence that intensive hoeing of sugar-beet or kale is detrimental to the yield. Two to three hoeings appear to be ample.

XX. E. W. Russell and N. P. Mehta. "*Studies in Soil Cultivation. VIII. The Influence of the Seed Bed on Crop Growth.*" Journal of Agricultural Science, 1938, Vol. XXVIII, pp. 272-298.

Crops germinate faster on the looser seed bed prepared by a Rototiller than on the more compact ones prepared by a plough or a grubber. The total number of plants that germinate is, however, the same for all treatments unless the land is too foul with weeds, when higher germination is obtained on the cleaner plots.

Cereals tend to ripen a little sooner on land that has been ploughed than on land that has been either rototilled or grubbed.

The roots of mangolds were longest and thinnest on the deep-ploughed plots and were always squatter on the shallow-tilled than on the deep-tilled plots. The roots were heaviest on the deep-ploughed plots and lightest on the rototilled plots. On the rototilled and the grubbed plots the depth of tillage had no effect. The plants on the shallow-grubbed plots seemed, however, to have no reserve of strength, for they could not make better growth if given more room, while those on the deep-grubbed plots could make some use and those on the ploughed or rototilled plots appreciable use of extra space.

Weeds tend to accumulate on the rototilled and the grubbed plots since neither grubbers nor rotary cultivators carrying tines mounted on a horizontal shaft can bury weeds and weed seeds in the way that the plough can. If the land is fairly clean and in good heart this probably does not matter for several years, but it prevents either implement from completely displacing the plough.

A subsidiary result that emerged from these experiments is that if a thin crop is given a nitrogenous top dressing, the fertiliser may benefit the weeds more than the crop.

(*b*) Physical Properties

XXI. R. K. Schofield and J. V. Botelho da Costa. "*The Measurement of* p*F in Soil by Freezing Point.*" Journal of Agricultural Science, 1938, Vol. XXVIII, in the press.

Two procedures are described for ascertaining the relationship between the freezing point and moisture content of a soil. As the process of freezing dries the soil sample, it is necessary to estimate how much water has been frozen out of the soil at the moment when the freezing temperature is recorded.

One procedure embodies all the precautions which appear desirable when the greatest accuracy is required. The other is simple and rapid and yet accurate enough for routine estimation of the wilting coefficient.

XXII J. V. Botelho da Costa. "*A Critical Survey of Investigations on the 'Wilting Coefficient' of Soils.*" Journal of Agricultural Science, 1938, Vol. XXVIII, in the press.

The experiments of Briggs and Shantz led them to conclude that the "wilting coefficient" is a soil "constant" which is (*a*) independent of the kind of plant used as indicator; (*b*) independent of the conditions under which the plant was grown and (*c*) directly related to several other soil constants.

Subsequent research as well as an examination of their own results has shown that (*c*) is untrue, while (*a*) and (*b*) are substantially correct for hygrophytes and mesophytes. Earlier writers have been led to wrong conclusions regarding (*a*) and (*b*) through assuming (*c*) to be correct and through disregarding the particular nature of "permanent wilting" as defined by Briggs and Shantz.

The fact that considerable variation is to be found between the osmotic pressure in different plants, in different parts of the same plant and in the same part under different conditions, is not at variance with conclusions (*a*) and (*b*) when properly understood.

An important factor making for the substantial constancy of the "wilting coefficient" for a given soil is the extreme steepness of the curve connecting suction pressure and soil moisture content, in consequence of which differences of suction pressure of unquestionable significance from the standpoint of plant physiology give rise to differences in soil moisture content that are too small to be detected.

XXIII. J. V. Botelho da Costa. "*The Indirect Determination of the 'Wilting Coefficient' by the Freezing Point Method, and the Influence of the Salts upon the* p*F at that Critical Moisture Content.*" Journal of Agricultural Science, 1938, Vol. XXVIII, in the press.

The results obtained in the preliminary investigation were entirely confirmed, the *p*F at the "wilting coefficient," as measured by the modified freezing point method, varying from 4.0 to 4.4 (round figures), with an average of 4.2.

The variation observed bears no relation to the soil texture, neither can it be explained by uncertainties in the freezing point determinations which have proved to be accurately reproducible. Freezing point measurements after leaching, conductivity measurements and freezing point determinations in saturated soil and at the moisture equivalent proved that part of the variation is due to the presence of soluble salts, the more saline soils having a higher *p*F at the "wilting coefficient." When the salt content does not exceed about 500 p.p.m. the influence of the salts is hardly detectable, and the *p*F at the

" wilting coefficient " lies between 4.0 and 4.3. Besides unavoidable errors in the wilting experiments* several other factors may account for this variation. They are all the factors that have any rôle in the " history " of the soil. In view of these uncontrollable sources of error a variation of 0.3 *p*F units can be considered very small.

It can therefore be confidently concluded that in ordinary agricultural soils with a salt content of less than about 500 p.p.m. permanent wilting occurs when a critical *p*F value lying between 4.0 and 4.3 is reached.

This knowledge affords a new indirect method of determining the "wilting coefficient " by freezing point measurements in soils having less than about 500 p.p.m. of soluble salts. Both procedures described in Paper XXI above, are equally satisfactory for this purpose. As the *p*F curve is practically straight in the neighbourhood of the " wilting coefficient," two freezing point measurements (round about 1-2°C. freezing point depression) are enough for the indirect determination of the " wilting coefficient."

The method is incomparably less laborious than the direct determination by wilting experiments and highly accurate.

XXIV. G. W. Scott Blair. " *Compressibility Curves as a Quantitative Measure of Soil Tilth.*" Journal of Agricultural Science, 1937, Vol. XXVII, pp. 541-556.

A preliminary account is given of experiments on the compressibility of soils in field condition, and two methods for obtaining compressibility curves, one for the field and one for the laboratory, are described. The laboratory apparatus automatically draws a curve relating deformation to the square root of the load built up. The theoretical relationship between load and deformation is discussed, the conclusions reached being at this stage semi-quantitative. Laboratory compression curves indicate the characteristics of soils in various states of tilth, and the effects of drainage condition, frost action, etc. Such factors as size of soil crumb, depth of layer tested, and moisture content of soil samples for laboratory studies are considered.

Preliminary field experiments are described in which the effects of simple cultivation processes on soil compressibility were measured.

XXV. G. W. Scott Blair and G. H. Cashen. " *Compressibility Curves as a Quantitative Measure of Soil Tilth. II.*" Journal of Agricultural Science, 1938, Vol. XXVIII, pp. 367-378.

The method described in an earlier paper for measuring the compressibility of soils *in situ* has been used to study the gradual consolidation of soil following digging with a fork, and a new method is described in which the rate of flow of water through rubber tubes buried in the soil gives a measure of compression.

By means of this latter method some measure can be obtained of the changes that take place in the soil after it has been loaded and trampled.

The results of the experiments confirm and amplify the earlier conclusions. At present it is hard to distinguish quantitatively the effects of moisture and time ; but it appears that differences in moisture for the range of stress used hardly affect the compressibility of newly dug soils, whereas in soils which have rested for some time since cultivation the compressibility is much increased by an increase in moisture content.

XXVI. J. R. H. Coutts. " *The Measurement of Soil Colours.*" Soil Research, 1937, Vol. V, pp. 295-307.

Four means were used to obtain quantitative measures of the colours of a group of Natal soils : (1) the Ostwald colour atlas ; (2) the Ridgway colour atlas ; (3) the Maxwell spinning disc ; and (4) the Lovibond tintometer. The relative advantages of the different methods are discussed. A direct comparison with the colour atlases gave the least dependable results. The Maxwell disc in the form recommended by the Soil Colour Committee of the American Soil Survey Association does not enable all soil colours to be matched. The Lovibond tintometer is convenient, and no failures to obtain a match with it have been found. It is suggested that the suitability of the tintometer should receive further consideration.

* A difference of 1 per cent. moisture content corresponds to a difference of 0.1 to 0.2 *p*F units in the neighbourhood of the " wilting coefficient."

(c) Analysis

XXVII. G. Nagelschmidt. "*X-Ray Investigations on Clays, Part III. The Differentiation of Micas by X-Ray Powder Photographs.*" Zeitschrift für Kristallographie, 1937, Vol. (A) XCVII, pp. 514-521.

In using the X-ray powder method for studying the minerals in soil fractions it is desirable to know the variability of the powder diagrams of minerals which vary in chemical composition but belong to one mineral family. Powder diagrams of eight micas of different chemical composition, including two lithium micas and sericite, are recorded. They all belong to either of two types, muscovite and phlogopite-biotite. From powder diagrams it should be possible to recognise mica in mixtures with either quartz or kaolin, and, if the mica forms half or more of the mixture, to distinguish between the two types of mica.

XXVIII. L. A. Dean. "*An Attempted Fractionation of the Soil Phosphorus.*" Journal of Agricultural Science, 1938, Vol. XXVIII, pp. 234-246.

Soils were extracted by sodium hydroxide and colorimetric methods employed to estimate the organic and inorganic phosphorus in the extract. The amount of phosphorus soluble in sodium hydroxide solution is influenced by the active soil calcium and it is suggested that sodium-saturated soils should be used when studying the alkali-soluble phosphorus. Relatively large amounts of organic phosphorus were found in most soils and generally followed the carbon contents of the soils. The acid-soluble phosphorus remaining after alkaline extraction appears to be similar to apatites. The largest fraction of the soil phosphorus was not dissolved by the sodium hydroxide and acid extractions. This fraction was not influenced by the long-continued use of phosphatic fertilisers at Rothamsted and Woburn.

XXIX. E. B. Kidson. "*Some Factors Influencing the Cobalt Contents of Soils.*" Journal of the Society of Chemical Industry, 1938, Vol. LVII, pp. 95-96.

Evidence has been obtained to show that the cobalt content of a wide variety of soils is in general related to the magnesium contents of their parent rocks: e.g., serpentine, rich in magnesium, gives soils with high cobalt contents and soils derived from granite have low cobalt contents. Manurial treatments for long periods on the Rothamsted and Woburn continuous wheat and barley plots have negligible effects on the cobalt contents of the soils. Soils from the Dartmoor area, on which sheep suffer from "pining" disease, have low contents (3-4 p.p.m.) of cobalt whereas healthy soils contain 11-30 p.p.m. This series of soils forms an interesting comparison with soils from New Zealand on which "bush sickness" occurs.

XXX. C. N. Acharya. "*Determination of the Furfuraldehyde Yield of Soils and of Plant Materials admixed with Soil.*" Biochemical Journal, 1937, Vol. XXXI, pp. 1800-1804.

A comparison is given of the bromine titration method of Powell & Whittaker and the gravimetric phloroglucinol method for the estimation of the total furfuraldehyde yield of soils and plant materials admixed with soil. In the absence of soil, the two methods were found to give concordant results. In presence of soil, however, low results were obtained by both methods, owing to the presence of oxidizing agents such as ferric and manganese compounds and nitrate in the soil, which apparently oxidize a portion of the furfuraldehyde during the course of distillation with 12 per cent. HCl. The addition of stannous chloride in regulated amounts reduces the oxidizing agents and prevents their interference.

It is concluded that for soils and plant materials mixed with soil estimation of the furfuraldehyde by precipitation with phloroglucinol, followed by extraction of the precipitate with boiling alcohol, is preferable to the bromine titration method of Powell & Whittaker.

XXXI. S. G. Heintze. "*Readily Soluble Manganese of Soils and Marsh Spot of Peas.*" Journal of Agricultural Science, 1938, Vol. XXVIII, pp. 175-186.

Marsh Spot disease of peas in the Romney Marsh area is more closely related to soil reaction than to soil series or soil texture. It was not found on any acid soil but on most of the alkaline ones in a representative set of 35 samples. Most of the soils contained appreciable amounts of free oxides of manganese and of salt-soluble manganese. The soils with Marsh Spot contained less salt-soluble manganese than the soils on which peas were healthy, but this relationship depended essentially on the contrast between acid and alkaline soils. Peas grown in pot cultures in manganese-deficient soils and in a sand-bentonite mixture developed Marsh Spot. Addition of manganese sulphate increased the manganese content of the seeds and controlled the disease.

Soils on which oats suffered from Grey Speck disease and sugar beet from " Speckled Yellow " contained little or no salt-soluble manganese.

THE PLANT IN DISEASE: CONTROL OF DISEASE

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

(*a*) Insects and Their Control

XXXII. C. B. Williams. "*The Migration of Day-flying Moths of the Genus* Urania *in Tropical America.*" Proceedings of the Royal Entomological Society of London, 1937, Vol. XII, pp. 141-147.

A number of new records of migration of *Urania leilus* and *Urania fulgeus* is given, and it is shown that the latter species is known in nearly all the central American countries from Mexico to Panama, and also in Columbia, Ecuador and Peru in western South America. There appear to be two flight seasons, and there is some evidence that the flights are more or less to the north in March and April and more or less to the east or south-east in June to September.

XXXIII. K. J. Grant. "*Some Recent Migrations of the Silver-Y. Moth.*" Transactions of the South Eastern Union of Scientific Societies, 1937, pp. 1-8.

An account is given of the evidence available on the migrations of *Plusia gamma* in 1932 to 1936. In 1936 there was a remarkable immigration and the species was seen as far north as the Shetland Islands. Immigrant swarms arrived in May and June and extensive damage was done to the sugar beet fields of Norfolk and Lincolnshire by the resulting larvae. During August and September migrations on a large scale were noted to both south and west.

The effect of wind on the flights is discussed and also the evidence that the Silver-Y. moth may survive the winter.

XXXIV. K. J. Grant. "*An Historical Study of the Migration of* Celerio lineata lineata *Fab. and* Celerio lineata livornica *Esp.* (*Lepidoptera*)." Transactions of the Royal Entomological Society of London, 1937, Vol. LXXXVI, pp. 345-357.

The distribution and outbreaks of the sub-species *Celerio lineata lineata* in America and *Celerio lineata livornica* in the Old World are described. It is suggested that both sub-species originate in semi-desert areas, and this idea is supported in the case of the American sub-species by the fact that a correlation exists between outbreaks of moths and a certain sequence of direct rainfall.

The main occurrences and outbreaks of both races in the past century are listed, and it is shown that a correlation exists between years of unusual abundance and unusual absence in the two continents. Outbreaks tend to occur simultaneously, and therefore their causes must be sought in some factor common to the two continents.

XXXV. C. B. Williams. "*The Use of Logarithms in the Interpretation of Certain Entomological Problems.*" Annals of Applied Biology, 1937, Vol. XXIV, pp. 404-414.

It is found that where catches of insects in a light trap are being examined statistically more consistent results are obtained if the logarithm of the catch number is used instead of the number itself. This also has the effect of reducing the swamping of a series of values by a single exceptionally large catch. The transformation appears to be made necessary by the fact that unit changes in the factors of the environment, such as temperatures, produce similar geometric or percentage changes in the catch.

XXXVI. H. F. BARNES. "*Methods of Investigating the Bionomics of the Common Crane Fly,* Tipula Paludosa, *together with some Results.*" Annals of Applied Biology, 1937, Vol. XXIV, pp. 356-368.

Full grown larvae were obtained by the O.D.B.C. method and reared to the adult stage on young wheat. The crane flies were mated and oviposition took place in glass tubes. The eggs were kept in solid watch glasses. The young larvae were reared on wheat rootlets, clover or chickweed leaves, pieces of cabbage leaf, slices of potato and bran in petri dishes. The breeding potential was as follows: 51 per cent. of the larvae emerged as adults, 75 per cent. of the available eggs were laid, 46 per cent. of the eggs hatched and 46 per cent. of the larvae survived the two first instars.

XXXVII. H. F. BARNES. "*The Asparagus Miner* (Melanagromyza Simplex H. *Loew*) (*Agromyzidae; Diptera*)." Annals of Applied Biology, 1937, Vol. XXIV, pp. 574-588.

The asparagus miner has two generations a year at Harpenden. The flies are on the wing from early June to the end of July and again from the beginning of August to mid-September. The larvae mine the stems of asparagus, but the damage is not serious except when it occurs in seedling beds or when it is followed by an attack of the larvae of *Lonchaea flavidipennis* Zett. Three parasites, a braconid *Dacnusa ?bathyzona* Marsh, a pteromalid *Sphegigaster* sp. and a eulophid *Pleurotropis epigonus* Walk were found. The fly is generally distributed in asparagus growing areas in England, U.S.A. and Europe.

XXXVIII. H. F. BARNES. "*The Hollyhock Seed Moth* (Platyedra malvella) *together with Notes on the Distribution of* Apion radiolus *Kirby and an Associated* Clinodiplosis *Species.*" Annals of Applied Biology, 1937, Vol. XXIV, pp. 589-599.

The life cycle of the moth is described. There is one generation a year, the moths being on the wing late in June until the beginning of August. The larvae feed on the seeds of hollyhock perforating them characteristically. The winter is spent in the soil, in May they become active again pupating towards the end of May and in June. An ichneumonid parasite *Angitia rufipes* Grav. was recorded. The moth is only found in the south-eastern counties of England. The *Apion* beetle and *Clinodiplosis* midge are found all over England, the latter also occurring in Wales and Ireland.

XXXIX. A. M. LYSAGHT. "*An Ecological Study of a Thrips* (Aptino Thrips Rufus) *and its Nematode Parasite* (Anguillulina Aptini)." Journal of Animal Ecology, 1937, Vol. VI, pp. 169-192.

Aptino Thrips rufus is abundant on the grass plots of the classical Park Grass at Rothamsted. Sampling has been carried out for two years on a number of plots and population counts made. *A. rufus* is parasitised by an eelworm *Anguillulina aptini*, on which some experimental work is described. The nematode was rarely found on two of the plots and this difference was found to be constant in two years. There is a rank growth of *Holcus lanatus* on these plots and this seems to have an unfavourable influence on the eelworm. Infected insects have, however, been found on *H. lanatus* under greenhouse conditions. Other factors, and particularly liming, that might affect the distribution are discussed.

XL. B. LOVIBOND. "*Investigation on the Control of Leather Jackets. II. Notes on Crane flies and their Larvae.*" Journal of the Board Greenkeeping Research, 1937, Vol. V, pp. 12-17.

Several species of crane flies have been reported as injurious in the larval stages in this country. An attempt is being made, by the rearing of samples of grubs, to determine the species which are injurious to golf greens—it being

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impossible at present to distinguish the species from an examination of the larvae. Suggestions have been put forward that the trapping of adults by light traps would serve to reduce the larval population. Examination of light trap material shows that in the case of *T. paludosa* the females had laid approximately 95 per cent. of their eggs before trapping. Hence this control measure is valueless for this species. Experiments with the St. Ives exterminator show that there is a tendency for the efficiency of the exterminator to vary with the age of the grubs. Thus the time of application is important from the point of view of efficient control.

XLI. B. LOVIBOND. "*Investigations on the Control of Leather Jackets. III. Some Results of Breeding and Sampling Experiments during the Current Season.*" Journal of the Board of Greenkeeping Research, 1937, Vol. V, pp. 107-112.

The rearing of samples of leather jackets from various golf courses confirms the view that *T. paludosa* is the most prevalent species, although other species do occur. In many cases there is a considerable amount of parasitism, but it is not sufficient to effect any appreciable decrease in the population. It is easy to distinguish between the eggs of *T. paludosa*, *T. oleracca* and *T. vernalis*. These species also differ in such details as number of eggs and incubation period, etc.

Repeated sampling of shows that there is a tendency for grubs to move to free areas from adjacent populated areas.

XLII. F. TATTERSFIELD. "*Modern Developments in Research on Insecticides. Part I. General Survey.*" Journal of the Society of Chemical Industry, 1937, Vol. LVI, pp. 79T-85T.

A critical survey of recent work on insecticides. It covers many of the more important researches carried out here and in America.

Means of assessing toxicity of contact and stomach insecticides, the recently developed statistical technique, field trials, chemical developments, soil fumigation and mode of action of insecticides are dealt with.

XLIII. J. T. MARTIN. "*Modern Developments in Research on Insecticides. Part II. Insecticidal Plant Products.*" Journal of the Society of Chemical Industry, 1937, Vol. LVI, pp. 85T-91T.

An account of recent research work on these insecticides. The chemistry and proposals for the chemical evaluation of fish-poison plants and pyrethrum are surveyed.

XLIV. S. G. JARY, J. T. MARTIN and F. TATTERSFIELD. "*The Artificial Drying of Pyrethrum Flowers.*" Journal of the South-Eastern Agricultural College, Wye, Kent, 1937, pp. 108-114.

An account of a joint experiment between the South-Eastern Agricultural College, Wye, Kent, and Rothamsted Experimental Station upon the drying of pyrethrum flowers at different temperatures in an experimental hop kiln.

The apparatus used is described and the pyrethrin content of the kiln-dried flowers given for a comparison with their air-dried controls.

There is a loss of pyrethrins in the sample dried at 45°C. (113°F.) for 21 hours and in those dried at 68°C. (154°F.) and 75°C. (167°F.) for 5¾ and 3½ hours respectively. There is little or no loss of pyrethrins in samples dried at temperatures of 52°C. (126°F.) and 60°C. (140°F.), when comparisons are made with their air-dried controls.

XLV. J. T. MARTIN and C. POTTER. "*A Colourless Active Extract of Pyrethrum Flowers.*" Journal of the Society of Chemical Industry, 1937, Vol. LVI, pp. 119-120.

A brief account of the preparation of a colourless extract of pyrethrum by extracting the powdered flowers in the presence of absorbent charcoal with light petroleum. The colourless extract was highly toxic to larvae of *Plodia interpunctella*.

XLVI. F. TATTERSFIELD and J. T. MARTIN. "*An Optically Active Constituent of* Derris *Resin related to Toxicarol.*" Journal of the Society of Chemical Industry, 1937, Vol. LVI, p. 77T.

A brief account of the isolation and some of the properties of the crystalline precursor of toxicarol.

(b) FUNGUS DISEASES

XLVII. G. SAMUEL and F. J. GREANEY. "*Some Observations on the Occurrence of* Fusarium Culmorum *on Wheat.*" Transactions of the British Mycological Society, 1937, Vol. XXI, pp. 114-117.

This fungus, which is known to be significantly pathogenic on oats and wheat under certain conditions, was found present on healthy wheat plants at the time of flowering, and increased in amount as the season advanced, as many as 70 per cent. of the plants examined being found infected before harvest. Although the fungus must have been present in the soil from the start, and was shown to be potentially parasitic, it had invaded the plants parasitically, only as the roots began to lose viability after flowering. Yet in other districts, e.g., the North of England, it causes appreciable injury. The cause of the difference, perhaps a soil condition, is not known.

XLVIII. S. D. GARRETT. "*Soil Conditions and the Take-all Disease of Wheat. II. The Relation between Soil Reaction and Soil Aeration.*" Annals of Applied Biology, 1937, Vol. XXIV, pp. 747-751.

By forced aeration acid soils can be rendered quite as favourable for the growth of *Ophiobolus graminis* along the roots of wheat seedlings as alkaline soils. This agrees with the hypothesis that such growth along the wheat roots in acid soils is retarded by the accumulation of respiratory carbon dioxide.

XLIX. S. D. GARRETT. "*Brom-thymol Blue in Aqueous Sodium Hydroxide as a Clearing and Staining Agent for Fungus-infected Roots.*" Annals of Botany, 1937, Vol. I, p. 563.

A note on a useful method.

L. J. SINGH. "*Soil Fungi and Actinomycetes in Relation to Manurial Treatment, Season and Crop.*" Annals of Applied Biology, 1937, Vol. XXIV, pp. 154-168.

A direct correlation was found between soil fertility as measured by crop growth (mangolds, wheat) and the number of fungi and actinomycetes in the soil; but evidence as to periodicity in these numbers was inconclusive. There is no support for the view that particular manurial treatments produce specific fungus flora.

(c) VIRUS DISEASES

LI. J. HENDERSON SMITH and F. C. BAWDEN. "*Discussion on Recent Work on Heavy Proteins in Virus Infection and its Bearing on the Nature of Viruses.*" Proceedings of the Royal Society of Medicine, 1938, Vol. XXXI, pp. 199-210.

Our knowledge of the nature of viruses has been greatly deepened in the last few years. The virus of tobacco mosaic has now been shown to be a nucleo protein, which when sufficiently purified exists in a liquid crystalline state, showing permanent birefringence if in relatively high concentration and anisotropy of flow when the concentration is reduced. This indicates that the constituent particles are rod-shaped, and X-ray analysis has given the measurements of their width. From solutions of the protein needle-shaped paracrystals or fibres are readily obtained, which are visible under the microscope, and in certain conditions mesomorphic fibrils are produced which are visible to the naked eye. In the process of purification the protein undergoes a linear aggregation, but in the plant there is good reason to believe that it exists in a less aggregated state. When fully purified it appears to be homogeneous, and there is no valid reason to doubt that the protein is actually the virus. It has all the properties of tobacco mosaic virus, except for a loss of filterability due to the aggregation, and reproduces the disease in indefinitely extensible series. It does not occur in normal plants, but in the infected plant it is found in quantities as large as 2g. per litre of sap, and has a molecular weight of the order of 20 millions. Similar proteins have been isolated from three strains of tobacco mosaic and two strains of cucumber mosaic, the individual proteins exhibiting characteristic differences just as the diseases they produce are characteristically distinct.

LII. F. C. BAWDEN and N. W. PIRIE. *"The Isolation and Some Properties of Liquid Crystalline Substances from Solanaceous Plants Infected with Three Strains of Tobacco Mosaic Virus."* Proceedings of the Royal Society of London, 1937, Vol. CXXIII, pp. 274-320.

Nucleo-proteins with characteristic optical properties were isolated from solanaceous plants infected with three strains of tobacco mosaic virus, but not from healthy plants. They are infective at a dilution of $1/10^{10}$, and give specific precipitates with antisera at a dilution of $1/10^{7}$. Solutions of the purified proteins separate into two layers if the protein content is raised above about 2 per cent. The lower layer is the more concentrated and is birefringent, while the upper shows anisotropy of flow. There is no essential difference in the virus activity, expressed in solid content, of the two layers. The anisotropy of flow can be easily recognised in solutions containing only 0.02 per cent. of protein. When centrifuged at high speed these solutions deposit the protein in the form of a birefringent jelly.

No enzyme preparation has yet been found which attacks these proteins at an appreciable rate, but the activity can be affected by a number of chemical agents. The stability towards heat and drying has been studied, and the conditions under which the nucleic acid-protein complex breaks down.

The physical properties of virus preparations and the X-ray measurements on them are interpreted on the theory that in purified preparations the constituent particles are rod-shaped, and it is suggested that these rods are built up by the linear aggregation of smaller units. There is evidence that, in the plant, part at least of the virus is not aggregated, for filters which pass an infectious filtrate with untreated plant sap do not do so with purified preparations

LIII. F. C. BAWDEN and N. W. PIRIE. *"The Relationships between Liquid Crystalline Preparations of Cucumber Viruses 3 and 4 and Strains of Tobacco Mosaic Virus."* British Journal of Experimental Pathology, 1937, Vol. XVIII, pp. 275-290.

Methods are described for the isolation of nucleo-proteins from cucumber plants infected with cucumber viruses 3 and 4. These have not been isolated from uninfected plants, and the evidence available indicates that they are the viruses themselves. Infections were obtained with 10^{-10}g., and specific precipitates with antiserum with $1/8 \times 10^{-6}$g. Concentrated solutions are spontaneously birefringent and dilute solutions show anisotropy of flow; when sedimented by high-speed centrifugation they form birefringent jellies, and when precipitated with acid or ammonium sulphate they form needle-shaped para-crystals. Although these viruses have a distinct host range from tobacco mosaic virus, the purified preparations have similar chemical compositions and many properties in common with purified preparations of strains of tobacco mosaic virus; they differ from tobacco mosaic virus, however, more widely than the recognised strains of tobacco mosaic virus differ from each other. The cucumber viruses and the tobacco mosaic viruses have certain antigens in common; the results of cross-absorption experiments between the various viruses and their antisera are described and provisional antigenic formulae suggested. Possible methods of relating and distinguishing between viruses and the relationship between the cucumber and tobacco viruses are discussed.

LIV. F. C. BAWDEN and N. W. PIRIE. *"A Note on Anaphylaxis with Tobacco Mosaic Virus Preparations."* British Journal of Experimental Pathology, 1937, Vol. XVIII, pp. 290-291.

Normal tobacco protein is anaphylactogenic but tobacco mosaic virus is not. That virus purified by ammonium sulphate precipitation may still retain a normal protein impurity which is removable by tryptic digestion can be demonstrated by the anaphylactic reaction.

LV. M. A. WATSON. "*Field Experiments on the Control of Aphis-transmitted Virus Diseases of* Hyoscyamus Niger." Annals of Applied Biology, 1937, Vol. XXIV, pp. 557-573.

Aphis-infestation of the first year's growth of *Hyoscyamus* (grown as a biennial crop) was reduced by spraying with nicotine and soft soap for the first eight or nine weeks. The greatest effect was obtained by spraying at weekly intervals. The percentage of infection was lower on the sprayed than on the unsprayed plots. The first cropping in the first year showed no effect on yield as the result of the treatment ; but in the second year a 30 per cent. increase of yield was obtained.

APICULTURAL PROBLEMS

(Sections for Bee Investigations and Biochemistry, and Bacteriology Department)

LVI. H. L. A. TARR. "*Studies on European Foul Brood of Bees. III. Further Experiments on the Production of the Disease.*" Annals of Applied Biology, 1937, Vol. XXIV, pp. 614-626.

Evidence is submitted which supports the theory that European Foul Brood is a single disease caused by *Bacillus pluton* White. The course of the disease can be modified by introducing cultures of certain secondary invading bacteria into colonies of bees infected with *B. pluton*. A certain "mass inoculum" of *B. pluton* organisms is required to induce the disease in healthy colonies. The causal organism is present in a virulent form in the rectal ampullae of young bees in affected colonies ; but does not appear to exist elsewhere in the bee, or to multiply in its intestinal tract. It appears as if *B. pluton* is a strict parasite which will only multiply in the intestines of young larvae.

LVII. H. L. A. TARR. "*Studies on American Foul Brood of Bees. I. The Relative Pathogenicity of Vegetative Cells and Endospores of* Bacillus Larvae *for the Brood of the Bee.*" Annals of Applied Biology, 1937, Vol. XXIV, pp. 377-384.

Vegetative cells of *Bacillus larvae* have not produced American Foul Brood in healthy nuclei of bees even when a dose almost three thousand times greater than an inoculum of spores of the organism capable of causing the disease has been sprayed over the developing brood. A very much smaller inoculum of spores of *Bacillus larvae* is effective in producing American Foul Brood when the developing larvae of healthy nuclei are sprayed directly with them, than when the spores are fed in syrup to the bees.

LVIII. H. L. A. TARR. "*Addled Brood of Bees.*" Annals of Applied Biology, 1937, Vol. XXIV, pp. 369-376.

It is shown that "Addled Brood" of bees is not of an infectious nature but is produced by a defective queen and can be cured by re-queening.

LIX. C. R. MARSHALL and A. G. NORMAN. "*The Analysis of Mixtures of Glucose and Fructose with Special Reference to Honey.*" The Analyst, 1938, Vol. LXIII, pp. 315-323.

A procedure for the direct determination of glucose and fructose in mixtures is described, involving hypoiodite oxidation for glucose followed by a micro-copper reduction method for fructose. The behaviour of these sugars in a mixture is not precisely that of the sum of the individual components taken separately. No constant correction can be applied for fructose oxidised by the hypoiodite. From the analysis of known mixtures equations have been derived for amounts of glucose and fructose within the limits of 0.08-0.04 g. of each. The presence of small amounts of sucrose is without effect. Examples of the application of this method to some typical honeys are given.

LX. HUGH NICOL. "*A Test of Gas Tightness of Honey Jars.*" The Bee World, 1937, Vol. XVIII, pp. 103-105.

Some standard metal-capped glass containers for honey were tested by putting the closed containers in an atmosphere containing ammonia and watching for change of colour of a faintly acid indicator solution inside the honey-jars. No jar was found to be gas-tight. Hence, when fermentation occurs in storage the cause may possibly be due to absorption of atmospheric moisture through imperfect closures.

TECHNICAL AND OTHER PAPERS

GENERAL

LXI. R. K. SCHOFIELD. "*The Viscosity of Flour Dough.*" Proceedings of the Royal Society of London, A, 1937, Vol. CLXIII, pp. 334-337.

This is a contribution to a discussion on the viscosity of liquids held by the Royal Society. The results of the data originally published in the Journal of Physical Chemistry and abstracted as papers V, VI, and VII in the Rothamsted Report for 1932 and as paper XVIII in the 1936 Report were briefly summarised.

LXII. G. NAGELSCHMIDT. "*A New Calcium Silicophosphate.*" Journal of the Chemical Society, 1937, pp. 865-867.

A new compound with a chemical composition approximating to $7CaO.P_2O_5.2SiO_2$ was isolated from certain medium-soluble basic slags. Its optical and X-ray powder data are almost identical with those of synthetic calcium silicophosphate of approximate composition 8CaO, P_2O_5, $2.5SiO_2$ prepared by Trömel. The new silicophosphate, like the well-known silico-carnatite which is the main constituent of basic Bessemer slags, is readily soluble in citric acid.

LXIII. K. WARINGTON. "*Boron in Agriculture.*" Nature, 1937, Vol. CXL, p. 1016.

Attention is drawn to the rapidly growing list of plants for which boron is an essential element; water culture experiments at Rothamsted suggest that carrot can also be included.

LXIV. F. C. BAWDEN and N. W. PIRIE. "*Liquid Crystalline Preparations of Cucumber Viruses 3 and 4.*" Nature, 1937, Vol. CXXXIX, p. 546.

Nucleo proteins have been isolated from plants infected with these viruses, which are similar to those isolated from tobacco mosaic. The method of isolation is described, and the physical properties detailed. Fuller particulars are given in paper LIII, above.

LXV. E. J. RUSSELL. "*Methods in Scientific Research.*" Indian Association for the Cultivation of Science, March, 1937.

LXVI. E. J. RUSSELL. "*Modern Movements in Agricultural Science.*" Calcutta Review, 1937, Vol. LXII, pp. 230-238.

LXVII. E. J. RUSSELL. "*Les Rapports des Bureaux Imperiaux de l'Empire Britannique avec less Travaux des Departements d'Agriculture d'Outre-Mer.*" Annales Agronomiques, 1938, Vol. VIII, pp. 149-157.

LXVIII. E. J. RUSSELL. "*Farming in Soviet Russia.*" Journal of the Ministry of Agriculture, 1938, Vol. XLIV, pp. 1063-1072.

LXIX. E. J. RUSSELL. "*The Farming Problem in Russia: How it is Being Met.*" Slavonic Review, 1938, Vol. XVI, No. 47.

LXX. E. J. RUSSELL. "*Poland Revisited.*" Journal of the Manchester Geographical Society, 1937, Vol. XLVII, pp. 11-38.

LXXI. B. A. KEEN. "*Blue Sun during Dust Storm.*" Quarterly Journal of the Royal Meteorological Society, 1937, Vol. LXIII, p. 338.

LXXII. B. A. KEEN. "*Agriculture on the Screen.*" Sight and Sound, 1937, Vol. VI, pp. 40-42.

LXXIII. R. K. SCHOFIELD. "*The Errors of Flow-meters and the Advantages of a New Type of Constriction.*" Proceedings of the Royal Society of Medicine, 1937, Vol. XXXI, pp. 443-445.

LXXIV. W. E. BRENCHLEY. "*Openings for Women in Scientific Research.*" Women's Employment, Feb. 18th, 1938, pp. 76-78.

CROPS, SOILS AND FERTILISERS

LXXV. F. M. L. SHEFFIELD. "*Stade Initial du Développement de la Fibre de Coton.*" Coton et Culture Cotonniere, 1937, Vol. XI, pp. 1-19.

A cytological examination, with illustrations, is given of the development of the fibre from primordial cells in the epidermis from the date of the opening of the flower. Emphasis is laid on the variability from cell to cell in a single seed, and from seed to seed within a single cell.

LXXVI. F. YATES and W. G. COCHRAN. "*Sampling Observations on Wheat.*" Journal of the Ministry of Agriculture, 1937, Vol. XLIII, pp. 1128-1129; Vol. XLIV, pp. 314-316, 701-706.

LXXVII. W. E. BRENCHLEY. "*Some Deficiency Diseases of Crop Plants.*" Journal of the Ministry of Agriculture, 1937, Vol. XLIV., pp. 116-122.

LXXVIII. W. E. BRENCHLEY. "*Boron and the Control of Plant Disease.*" Nature, 1937, Vol. CXXXIX, pp. 536-537.

LXXIX. W. E. BRENCHLEY. "*Pasture Problems.*" Nature, 1937, Vol. CXL., pp. 918-919.

LXXX. HUGH NICOL. "*Synthetic Substances that Regulate Growth in Plants.*" Manufacturing Chemist, 1937, Vol. VIII. *Part I*: "*Synthesis,*" pp. 175-180. *Part II*: "*Some Effects and Modes of Application,*" pp. 211-216. *Part III*, "*Uptake from Soil: Natural Sources, Nomenclature,*" pp. 254-257.

LXXXI. H. L. RICHARDSON. "*The Examination of Soils by Screened Ultra-Violet Light.*" Soil Research, 1937, Vol. V, pp. 308-310.

In all soils, except those heavily impregnated with salts, the soil-material as a whole was non-fluorescent. Small rootlets and other fragments of structural organic matter fluoresced brightly. The salts in saline soils fluoresced sufficiently to make them more readily visible by ultra-violet than by ordinary light.

LXXXII. B. A. KEEN. "*New Views on Drainage.*" The Farmer and Stock-Breeder, 1938, Vol. LII, p. 740.

LXXXIII. B. A. KEEN. "*The Circulation of Water in the Soil between the Surface and the Level of Underground Water.* Sixième Assemblée Génerale à Edinbourg de l'Association Internationale d'Hydrologie Scientifique, 1936, Bull. 22, pp. 37-48.

LXXXIV. B. A. KEEN and E. W. RUSSELL. "*Are Cultivation Standards Wastefully High?*" Journal of the Royal Agricultural Society of England, 1937, Vol. XCVIII, pp. 53-60.

LXXXV. E. W. RUSSELL. "*The Physical Basis of Soil Structure.*" Science Progress, 1938, Vol. XXXII, pp. 660-676.

LXXXVI. B. A. KEEN. "*Why Soil needs Lime.*" The Farmer and Stock-Breeder, 1938, Vol. LII, p. 471.

LXXXVII. H. V. GARNER. "*The Effect of Manures on the Size of Main Crop Potatoes.*" Empire Journal of Experimental Agriculture, 1937, Vol. V, pp. 327-341.

LXXXVIII. H. V. GARNER. "*Fertiliser Trials at Schools—Further Experience with Microplots.*" School Science Review, 1937, Vol. XIX, pp. 258-265.

LXXXIX. H. V. GARNER. "*Composts.*" Journal of the Ministry of Agriculture, 1937, Vol. XLIV, pp. 330-334.

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XC. H. V. GARNER. "*The Distribution of Fertilisers.*" The Third Oxford Farming Conference, 1938, pp. 64-69.

XCI. E. M. CROWTHER. "*Soils and Fertilisers.*" Reports on the Progress of Applied Chemistry, 1937, Vol. XXII, pp. 573-603.

XCII. E. J. RUSSELL. "*Soils and Fertilisers.*" The Farmer's Guide to Agricultural Research in 1936. Royal Agricultural Society of England, 1937, pp. 197-244.

BIOLOGICAL

XCIII. F. C. BAWDEN. "*Plant Viruses.*" Biology, 1937, Vol. III, pp. 349-355.

XCIV. S. D. GARRETT. "*The Soil-borne Fungus Diseases of Field and Plantation Crops : A Review of Existing Control Methods.*" Empire Journal of Experimental Agriculture, 1937, Vol.V, pp. 189-196.

XCV. G. SAMUEL. "*Whiteheads or Take-all in Wheat.*" Journal of the Ministry of Agriculture, 1937, Vol. XLIV, pp. 231-241.

XCVI. C. B. WILLIAMS. "*The Work of the Entomological Department at Rothamsted,* 1918-1936." Rothamsted Annual Report for 1936, pp. 99-120.

XCVII. H. F. BARNES. "*Check List of the Cecidomyidae of Oceania.*" Occasional Papers of the Bernice Pauahi Bishop Museum, 1937, Vol. XIII, p. 62.

XCVIII. H. F. BARNES. "*Check List of the Cecidomyidae of New Zealand.*" Transactions of the Royal Society of New Zealand, 1937, Vol. LXVII, pp. 115-121.

XCIX. H. F. BARNES. "*Insects and Other Pests Injurious to the Production of Seed in Herbage and Forage Crops.*" Imperial Agricultural Bureaux Herbage Publications Series, 1937, Bull. 20.

C. K. D. BAWEJA. "*The Calculation of Soil Population Figures.*" Journal of Animal Ecology, 1937, Vol. VI, pp. 366-367.

CI. H. L. A. TARR. "*Brood Diseases of the Bee. I. Distribution of the Various Diseases of the Brood in Different Countries.*" Tabulae Biologicae, 1937, Vol. XIV, pp. 150-185.

CII. H. L. A. TARR. "*Certain Factors Influencing the Germination of the Endospores of* Bacillus Larvae." The Bee World, 1937, Vol. XVIII, pp. 57-58.

CIII. H. L. A. TARR. "*Brood Diseases of Bees Investigations.*" The Bee World, 1937, Vol. XVIII, pp. 110-112.

An abridged report on the brood disease investigation for the year ending September 30th, 1937.

CIV. H. L. A. TARR. "*The Resistance of Individual Larvae to Inoculation with Large Doses of the Spores of* Bacillus Larvae." The Bee World, 1937, Vol. XVIII, pp. 115-116.

WOBURN EXPERIMENTAL FARM REPORT FOR 1936-7

BY DR. H. H. MANN

Season

The season of 1936-37 was a very wet one, especially in the early spring, and in the autumn. This made the sowing of spring crops difficult, though the relatively dry period in the summer itself made both the hay time and harvest fairly successful. This dry period, however, caused the sowing of kale and other similar fodder crops to be unsatisfactory, especially when they could not be planted before June. The meteorological records from October 1936 to the end of 1937 were as follows :

METEOROLOGICAL RECORDS FOR 1936-37

Month	*Rainfall* Total Fall	No. of Rainy Days	Bright Sun-shine	*Temperature (Mean)* Maxi-mum	Mini-mum	1 ft. in Ground	Grass Mini-mum
1936	Ins.		Hours	°F.	°F.	°F.	°F.
Oct. ..	1.80	17	110.3	55.5	40.4	49.1	36.0
Nov. ..	2.14	17	44.3	47.0	34.7	43.3	32.6
Dec. ..	1.38	16	51.5	46.1	34.9	40.5	31.2
1937							
Jan. ..	3.16	24	50.8	45.6	35.2	40.7	32.0
Feb. ..	4.16	22	64.7	47.3	36.8	40.7	30.4
Mar. ..	3.27	21	104.3	44.0	31.3	39.2	28.3
April..	2.54	15	96.4	54.3	40.4	47.9	38.0
May ..	3.94	16	166.7	61.5	45.5	55.5	43.4
June ..	1.49	10	178.9	66.0	47.8	63.2	44.8
July ..	1.21	9	128.4	68.9	53.3	64.4	50.0
Aug. ..	2.36	5	199.5	72.5	52.8	66.5	48.5
Sept...	1.46	16	150.2	64.1	46.4	58.3	42.1
Oct. ..	2.75	12	73.7	57.5	42.1	51.3	37.5
Nov. ..	1.84	11	59.4	46.6	34.0	43.0	30.7
Dec. ..	2.44	23	28.7	41.1	31.8	38.6	29.1
Total or mean for 1937 ..	30.62	184	1301.7	55.8	41.4	50.8	37.9

CONTINUOUS WHEAT AND BARLEY EXPERIMENTS

The present interest of these experiments, which have been carried on ever since 1877, resides chiefly in the study of the effect of fallowing, without further manure, on the crops of wheat or barley. Two fallows have been taken in recent years, namely in 1926 and 1927, and again in 1934 and 1935. The crop in 1937 was thus the second after a two year fallow, and thus assists in determining how far the previous manuring for fifty years has affected the power of recovery of the soil through fallowing.

(*a*) *Continuous Wheat.* " Red Standard " wheat was sown in October, and a good plant was obtained and developed normally. The only difficulty in growing it was the excessive growth of wild vetchling (*Vicia hirsuta*) on certain plots, notably on plots 6, 9 and

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11b. The infestation by this weed was little improved by the two years' fallow previously referred to.

TABLE I.

Continuous Growing of Wheat, 1937—after 2 years' (1934—1935) fallowing and previous fallowing, 1927 and 1928.

Stackyard Field — *Produce per acre*

Plot	Manures Applied Annually. (Before the Fallow.) For amounts see Report 1927-1928 No manures since 1926	Dressed corn per acre bushels	Total corn per acre lb.	Weight per bushel lb.	Straw, chaff, etc., per acre lb.
1	Unmanured	17.9	1,007	56.0	1,862
2a	Sulphate of ammonia	2.3	137	58.9	266
2aa	As 2a, with lime, Jan., 1905, repeated 1909, 1910, 1911	7.4	443	60.0	1,040
2b	As 2a, with lime, December, 1897	12.9	770	59.5	1,347
2bb	As 2 b, with lime, repeated Jan. 1905	12.8	758	59.0	1,330
3a	Nitrate of soda	14.0	837	59.5	1,472
3b	Nitrate of soda	11.5	687	59.5	1,133
4	Mineral manures (superphosphate and sulphate of potash)	18.6	1,053	56.5	1,922
5a	Mineral manures and sulphate of ammonia ..	8.5	508	60.0	1,045
5b	As 5a, with lime, Jan., 1905	13.5	795	59.0	1,614
6	Mineral manures and nitrate of soda	12.0	721	60.2	1,386
7	Unmanured	16.0	899	56.2	1,546
8a	Mineral manures and, in alternate years, sulphate of ammonia	1.2	72	58.9	218
8aa	As 8a, with lime, Jan., 1905, repeated Jan., 1918	5.4	306	60.0	685
8b	Mineral manures and sulphate of ammonia (omitted in alternate years)	1.8	105	58.9	218
8bb	As 8b, with lime, Jan., 1905, repeated Jan., 1918	lost	lost	lost	lost
9a	Mineral manures and, in alternate years, nitrate of soda	8.7	528	60.5	1,351
9b	Mineral manures and nitrate of soda (omitted in alternate years)	8.3	496	59.2	2,080
10a	Superphosphate and nitrate of soda	12.4	729	58.5	1,219
10b	Rape dust	13.3	772	58.0	1,398
11a	Sulphate of potash and nitrate of soda	13.6	827	60.5	1,910
11b	Farmyard manure	11.6	681	58.5	1,807

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

Yield of dressed corn per acre

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

The recovery of the yield after the fallows is very striking, as well as the maintenance of the recovered yield for at least two years, in spite of the absence of any manuring since 1926. This applies to all plots except that which had farmyard manure for the first fifty years, and to the plots which have become acid through the use of sulphate of ammonia.

(*b*) *Continuous Barley*. The crop in **1937** was substantially a failure. The land in this case has become unworkable in a wet period, and as the early spring of **1937** was wet, it was impossible to get a good seed bed. Plumage Archer barley was sown on March **31**st, on a very bad tilth. The crop never flourished and the yield was barely worth recording. The following table gives the actual yields :

TABLE II

Continuous Growing of Barley, 1937—*after* 2 *years'* (1934-1935) *fallowing and previous fallowing*, 1927 *and* 1928

Stackyard Field *Produce per Acre*

Plot	Manures Applied Annually (Before the Fallow) For amounts see Report 1927-1928 No manures since 1926	Dressed corn per acre bushels	Total corn per acre lb.	Weight per bushel lb.	Straw, chaff, etc., per acre lb.
1	Unmanured	1.4	69	43.0	328
2a	Sulphate of ammonia	—	—	—	—
2aa	As 2a, with lime, Mar., 1905, repeated 1909, 1910, 1912 and 1923	4.3	184	41.0	596
2b	As 2a, with lime, Dec., 1897, repeated 1912 ..	1.2	56	44.8	195
2bb	As 2a, with lime, Dec., 1897, repeated Mar., 1905	2.3	104	44.8	308
3a	Nitrate of soda	2.5	112	44.8	376
3aa	As 3a, with lime, Jan. 1921	2.8	124	44.8	376
3b	Nitrate of soda	2.6	116	44.8	388
3bb	As 3b, with lime, Jan., 1921	2.2	100	44.8	244
4a	Mineral manures (superphosphate and sulphate of potash)	1.4	64	44.8	250
4b	As 4a, with lime, 1915	0.8	38	44.8	186
5a	Mineral manures and sulphate of ammonia ..	—	—	—	—
5aa	As 5a, with lime, Mar., 1905, repeated 1916 ..	2.4	108	44.8	180
5b	As 5a, with lime, Dec., 1897, repeated 1912 ..	1.2	54	44.8	170
6	Mineral manures and nitrate of soda	3.3	140	43.0	381
7	Unmanured	2.6	119	45.0	301
8a	Mineral manures and, in alternate years, sulphate of ammonia	—	—	—	—
8aa	As 8a, with lime, Dec., 1897, repeated 1912 ..	2.6	116	44.8	312
8b	Mineral manures and sulphate of ammonia (omitted in alternate years)	—	—	—	—
8bb	As 8b, with lime, Dec., 1897, repeated 1912 ..	2.5	112	44.8	328
9a	Mineral manures and, in alternate years, nitrate of soda	3.9	182	47.0	464
9b	Mineral manures and nitrate of soda (omitted in alternate years)	4.6	208	45.0	478
10a	Superphosphate and nitrate of soda	2.6	112	43.0	356
10b	Rape dust	1.7	78	[44.8	282
11a	Sulphate of potash and nitrate of soda ..	4.0	192	48.0	492
11b	Farmyard manure..	5.8	284	48.5	706

ROTATION EXPERIMENT

The rotation experiment on the relative value of farmyard manure made from a rich feeding stuff like oil cake and from less nitrogenous material like corn (which was the work for which the farm was originally opened) came to an end in **1937** after continuing for sixty-one years. The last crop, taken on Series C in Stackyard Field, was wheat, grown after alsike clover in **1936**. Red Standard wheat was sown on October **29**th, **1936**, and grew well, giving the following yields, per acre :

Plot	*Head Corn*		*Tail Corn*	*Straw, Chaff, etc.*
	Yield	Weight per Bushel.		
	bushels	lb.	lb.	cwt.
1. After cake-feeding	17.4	60.4	1	19.3
2. After corn-feeding	17.4	60.6	1	20.1

The final year, therefore, gave results which agree with those obtained throughout the experiment, indicating that the farmyard manure prepared from the richer materials does not carry its superiority as a manure beyond the first crop after it is applied.

GREEN MANURING EXPERIMENTS

The year under report was also the last year of one of the oldest experiments at Woburn, on the value of green manuring with tares or mustard as a preparation for wheat. This, which is in Lansome Field, has gone on ever since 1893, and has shown that two crops of green manures, applied every second year, even when supplemented by dressings of superphosphate and potash, are not sufficient to maintain the fertility of the land for wheat. The last crop of wheat in 1937 shows this as clearly as in any previous year. The variety of wheat was Red Standard, and it was sown on October 27th, 1936.

Yield of wheat per acre

Plots	Nitrogen in green manures	*Head Corn*		*Tail corn*	*Straw, chaff, etc.*
		Yield	Weight per bushel		
	lb.	bushels	lb.	lb.	lb.
1. Mustard, old series ..	26.3	7.1	60.5	4	1190
2. Tares, old series ..	37.8	9.4	57.4	2	1343
3. Mustard, new series ..	31.6	10.4	58.9	2	1851
4. Tares, new series ..	34.7	10.5	58.6	2	1455
5. Control ..	——	10.8	58.0	2	1918

New Green Manuring Experiment

In view of the unsatisfactory results obtained with green manuring with either tares or mustard as a preparation for wheat, a new experiment was designed in 1936 whereby these green manures, as well as clover and ryegrass, were used as a preparation for kale, two crops being taken in the previous winter and spring, and the kale being sown in or about June. At the same time, the use of farmyard manure (at the rate of ten tons per acre) and of straw (at the rate of 30 cwt. per acre) in conjunction with the green manures, was tested. Details of the results of the first two years of this experiment (1936 and 1937) will be found in the statistical section of this report. In this experiment, any residual value of the green manures and other additions may have on a succeeding crop of barley are also tested.

LUCERNE INOCULATION EXPERIMENT

In 1932 a series of plots was laid down to test the effect of inoculation of the seed on the yield and character of lucerne, and so 1932 is the sixth year of the growth of this crop. It may be stated at once that the results have shown no increase of yield

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due to the inoculation, though the nitrogen content of the fodder from the inoculated plots was greater in the earlier years. But the plots have continued to yield very heavy crops, and that of 1937 is one of the largest that have been obtained. The actual yields per acre in each of the six years, including 1937, on both the inoculated and the un-inoculated plots are shown in the following table. Three crops were obtained during the season, as usual.

Yield of lucerne hay per acre

	1932	1933	1934	1935	1936	1937	Total
	tons	tons	tons	tons	tons	tons	tons
Un-inoculated plots ..	0.70	3.28	4.07	6.55	4.37	5.02	23.99
Inoculated plots.. ..	0.68	3.12	3.96	6.48	4.29	4.98	23.51
Mean of all plots ..	0.69	3.20	4.01	6.52	4.33	5.00	23.75

This crop has been maintained by very thorough harrowing of the area after the final cutting has been taken each year, repeated several times during the succeeding winter, and, in the last three years, a dressing of farmyard manure (10 tons per acre) applied as a top dressing in January of each year. There is no sign, except at one end of the block, of the lucerne dying out after the end of six years.

OTHER EXPERIMENTS

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

1. *Six Course Rotation Experiment.* This has been carried out ever since 1930, using no outside organic manures, but applying varying quantities of nitrogen (in the form of sulphate of ammonia), potash (in the form of muriate of potash), and phosphoric acid (in the form of superphosphate) for each crop. 1937 is the eighth crop in this series.

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

3. *The Manuring of Market Garden Crops with Concentrated Organic and Other Nitrogenous Manures.* The crop used in 1937 was kale, and the manures investigated were soot, dried poultry manure, rape dust, compared with sulphate of ammonia.

POT CULTURE EXPERIMENTS

The main programme in the pot culture house was a continuation of work on problems which have arisen in connection with the field experiments. The experiments on "clover sickness" in different kinds of clover, begun in 1931, have now definitely established that the clover failure which is so common on the light soils of Woburn is something apart from eelworm attack, and also from damage by fungi, to which it is usually attributed, though these co-exist frequently with it. Heating of the soil to 135-140°F prevents for a time the advent of clover sickness, and also cures it, if present. In 1936, the still more important discovery was made that a liberal

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application of farmyard manure was successful in preventing clover sickness from appearing in the crop, while artificial manures had not a similar effect. The results will be published in the coming year.

The study of questions relating to acid soils, such as those produced by the continued use of sulphate of ammonia on a lime-deficient soil, have taken a good deal of time. Some of the important results are that (*a*) excellent crops of barley can be grown on these soils without any addition of lime, provided they receive a good dressing of farmyard manure, (*b*) the addition of calcium salts of any kind cannot replace the use of caustic lime or carbonate of lime in bringing back the fertility of acid soils, (*c*) even large dressings of phosphates do not bring back the fertility of these soils, though this has been stated by many workers on the subject.

Work has continued on the effect of manuring with various forms of organic material, chiefly those which might be used as green manures in comparison with farmyard manure and with sulphate of ammonia. These results do not lend themselves to a summary, but they will be published in the near future.

FARM REPORT

From the point of view of yield, the season of 1936-37 was, on the whole, a good one. All crops grew well, and spring grain crops did very well indeed. The rain came very awkwardly for things like sugar beet or potatoes, and, to an even greater extent, for kale and similar vegetables. But, in spite of this, good crops of all except kale were obtained over the greater part of the farm.

In Stackyard Field, the area known as Series D was fallowed in preparation for another experiment, and the year was suitable for this purpose. As a result, a very foul piece of land has become ready for further experimental cultivation. Similar measures will be taken with Series C in 1937-38.

As far as livestock is concerned, sheep did very well during the year, and the shepherd (W. McCallum) obtained the shepherd's prize for the county for the highest percentage of lambs to ewes (171 per cent.) in the lambing season of 1936-37. The year closed with a breeding flock of 61 ewes, all being cross bred, with one Hampshire ram.

As far as pigs are concerned, the herd was somewhat reduced in the year and the period closed with 186 animals. Awards were made to the farm at the Bedfordshire County Show for a bacon pig (first prize) and for sows (second and third prizes). Awards were also obtained at the fat stock shows at Bedford and Bletchley in December 1936.

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DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, WOBURN, 1937

Field	Crop	Variety	Principal Cultivations and Dates	Sowing Dates	Cutting or Raising Dates	Carting Dates	Manuring per acre	Yield per acre
1. *Arable* Butt Furlong (1)	Sugar Beet	Klein-wanzleben	Dec. 4-6, 1936—Plough: Apl. 28, 1937—Harrow: May 1—Sow and harrow: May 5—Roll: May 17-20—Hand-hoe: May 28-June 2—Single to 9 ins. apart: June 9-10—Horse-hoe: June 12—Apply Sulphate of Ammonia at 1 cwt. per acre: June 22-July 19—Hand-hoe at intervals: July 24 and onward–Hand-hoe, and weed.	May 1	Oct. 11 and at intervals afterwards	—	1 cwt. Sulphate of Ammonia	12 tons
(2)	Potatoes	Majestic	Sept. 29, 1936—Spring tine harrow wheat stubble: Oct. 22-24—Haul on 30 tons farmyard manure per acre and spread: Nov. 5-8—Plough: Apl. 19-20, 1937—Tractor cultivate: Apl. 24-27—Bout up and plant potatoes, and cover: May 8 and 27—Harrow: June 9—Horse-hoe: June 17-21—Hand-hoe: June 23-24—Bout up.	April 26	Oct. 1, and at intervals afterwards	—	30 tons dung. 2 cwt. Sulphate of Ammonia	6 tons
Butt Close (1)	Wheat	Red Standard Yeoman II, Sq. Head's Master	Oct. 15-17, 1936—Plough and double harrow: Oct. 27—Sow: Apl. 8-9, 1937—Harrow: Apl. 15 and 27—Apply Sulphate of Ammonia: Apl. 24 and 30—Harrow.	October 27 1936	August 4-5	August 12	2 cwt. Sulphate of Ammonia	Yeoman II. 21.9 cwt. Sq. Head's Master 21.1 cwt.
(2)	Carrots	Early Model and New Model	Feb. 15—Plough: Feb. 20-23—Harrow, roll, and sow with carrots: May 3-20—Hand-hoe: June 2—Apply Sulphate of Ammonia: June 9—Hand-hoe.	February 23	July 26	—	2 cwt. Sulphate of Ammonia	(Sold standing)

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, WOBURN, 1937 (*Continued*)

Field	Crop	Variety	Principal Cultivations and Dates	Sowing Dates	Cutting or Raising Dates	Carting Dates	Manuring per acre	Yield per acre
(3)	Barley	Plumage Archer	March—Plough, after cabbages, etc.: Apl. 5—Tractor cultivate and harrow: Apl. 5 and 24—Sow at 3 bush. per acre and harrow: May 5—Roll: May 14 and 20—Apply Sulphate of Ammonia.	April 5 and 24	August 17-18	August 26-27	1 cwt. Sulphate of Ammonia	24 cwt.
Lansome Piece (1)	Lucerne	Grimm	(Planted in 1932) Nov. 19, 30; Dec. 12, 31, 1936; Jan. 11, 1937—Harrow thoroughly on each occasion: Jan. 13—Haul on and spread manure: June 26—First Cutting: June 28 and July 5—Harrow: August 10—Second Cutting: Aug. 11 and 16—Harrow: Oct. 15—Third Cutting.	—	June 26 August 10 October 15	—	10 tons dung	5 tons lucerne hay
(2)	Green Manuring Wheat	Red Standard	Sept. 14-15, 1936—Plough: Oct. 19—Double Harrow: Oct. 27—Drill and harrow wheat: Apl. 5, 9, 28 and May 19—Harrow.	October 27, 1936	July 30	August 9	—	9.6 bushels
(3)	Brussels Sprouts and Cabbages		Nov. 6-12, 1936—Raise previous crop of sugar beet: Dec. 2-4—Spread beet tops: Dec. 3-30—Apply farmyard manure: Dec. 30-Jan. 5—Plough: May 10—Harrow: May 20-27—Plough: June 11-14—Harrow and plant Brussels Sprouts: June 15—Drill Cabbage on rest of area: July 7-8—Horse-hoe: July 20 and at intervals—Horse-hoe cabbage: July 29-30—Single cabbage: Aug. 10-12—Apply Sulphate of Ammonia.	Sprouts transplanted June 11: Cabbage sown — June 15	At intervals to February 5, 1938	—	25 tons dung 1 cwt. Sulphate of Ammonia	(Sold standing)

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, WOBURN, 1937 (*Continued*)

Field	Crop	Variety	Principal Cultivations and Dates	Sowing Dates	Cutting or Raising Dates	Carting Dates	Manuring per acre	Yield per acre
Stackyard Field (1)	Permanent Wheat	Red Standard	Sept. 17, 1936—Plough with tractor: Oct. 27—Harrow and sow wheat, and harrow: Apl. 7 and May 4, 1937—Harrow.	October 27, 1936	August 11	August 23	—	12.2 bushels
(2)	Permanent Barley	Plumage Archer	Sept. 7, 1936—Plough with tractor: Mar. 30, 1937—Harrow both ways with spring tine harrow: May 31—Harrow and sow (3 bush. per acre), and harrow: May 3—Roll and harrow: May 15—Harrow: May 24 to June 15—Hand-hoe at intervals.	March 31	August 23	August 27	—	2.4 bushels
(Series C) (3)	Wheat	Red Standard	Sept. 14-16, 1936—Plough with tractor Oct. 2, 19, 22, 28—Cross cultivate with tractor: Oct. 28—Cross cultivate and harrow: Oct. 29—Drill 3 bush. per acre wheat seed and harrow: Apl. 7, 8, 12, May 4-5—Harrow.	October 29, 1936	August 12	August 25	—	17.4 bushels

II. Grassland. All grassland was harrowed with the chain harrow in April 1937, and then rolled with the Cambridge roller. The following fields were then laid in for hay, which was cut as follows :—

Roadpiece Field—June 25 (S.W. end) and July 14 (rest of field).

Great Hill—June 9-10 (East end) and July 14 (rest of field).

Warren Field—July 1-3 (N. Paddock) and July 12-13 (rest of field)

Lansome Field (S.W)—June 12.

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

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, ROTHAMSTED, 1937

Field	Crop	Variety	Principal Cultivations and Dates	Manuring per acre	Sowing Dates	Cutting Dates	Carting Dates	Yield per acre
Arable Great Knott	Annual Experiments and Kale	Marrow Stem	T. cultivated both ways Sept. 25 H. ploughed April 7. T. rolled and spring harrowed twice June 2 and June 11. H. harrowed June 16. H. rolled, drilled, harrowed and rolled in kale at $4\frac{1}{2}$ lb. per acre June 7. H. hoed July 19. Commenced folding Sept. 14.	June 30 3 cwt. nitro-chalk July 22 2 cwt. sulphate of ammonia	June 17	—	—	15 tons
	and Wheat	Red Marvel	T. cultivated both ways Sept. 25. H. ploughed Nov. 25. T. spring tine harrowed April 9. Drilled and harrowed in wheat at 3 bush. per acre April 12.	April 27 1 cwt. sulphate of ammonia	April 12	August 30	Sept. 2	6 cwt.
Great Harpenden	Oats	Star and headlands Marvellous	T. cultivated Oct. 7. Commenced H. ploughing Jan. 7. Finished H. ploughing Mar. 5 T. spring tine harrow Mar. 26. H. harrow and drill oats at 4 bush. per acre April 12. Area under potatoes 1936 undersown with Montgomery Late Flowering Red Clover at 20 lb. per acre May 25.	April 13 1 cwt. sulphate of ammonia	April 12	August 16	August 31	19 cwt.
Fosters	Barley, and Kale and Ley Experiments	Plumage Archer	H. ploughed March 5-April 6. T. spring tine harrowed and disced April 12. H. harrow and drill barley at 3 bush. per acre April 23. H. ring roll April 26.	May 20 1 cwt. sulphate of ammonia	April 23	Sept.3	Sept. 7	11 cwt.
Little Hoos	Kale	Marrow Stem and Thousand Head	T. ploughed May 19. T. rolled and spring tine harrowed three times May 28-June 12. H. harrow and drill at $4\frac{1}{2}$ lb. per acre. H. harrow and ring roll June 15. H. hoe July 14 and Aug 9. Commence folding ewes Sept. 20.	June 22 $2\frac{1}{2}$ cwts. nitro-chalk July 22 $2\frac{1}{2}$ cwts. nitro-chalk	June 15	Sheep folded	—	20 tons

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, ROTHAMSTED, 1937 (*Continued*)

Field	Crop	Variety	Principal Cultivations and Dates	Manuring per acre	Sowing Dates	Cutting Dates	Carting Dates	Yield per acre
Pennell's Piece	Wheat	Victor	H. ploughed Sept. 28. H. harrowed Oct. 24. H. spring tine harrowed twice Nov. 10 and Nov. 23. H. harrowed, drilled and harrowed in wheat at 3 bush. per acre Nov. 24.	—	Nov. 24	August 16	August 24	18 cwt.
Pastures	Wheat	Victor	T. ploughed Oct. 9. Long stubble harrowed up, collected and carted off Oct. 12. T. spring tine harrowed Oct. 19. T. rolled and harrowed Oct. 20. H. harrowed, drilled and harrowed in wheat at 3 bush. per acre Oct. 22.	May 15 1 cwt. sulphate of ammonia	Oct. 22	August 16	August 25	15 cwt.
Long Hoos I, II, III	Wheat (3½ acres)	Victor	Spread dung after rye, Sept. 26. Commenced H. ploughing Sept. 28. Finished H. ploughing Oct. 14. T. spring tine harrowed Oct. 15. H. harrowed Oct. 16. Drilled and harrowed in wheat at 3 bushels per acre Oct. 18.	—	Oct. 18	August 10	August 24	18 cwt.
	and Barley (8½ acres)	Abed Kenia	Cut kale stalks April 22. T. ploughed April 22—May 1. T. disced, rolled and spring tine harrowed three times April 27—May 7. H. harrowed and rolled May 7. Drilled and harrowed in barley at 3 bushels per acre May 10. H. ring rolled June 4.	—	May 10	Sept. 2	Sept. 8	17 cwt.
Harwood's Piece	Wheat	Rivett	T. ploughed Oct. 15. T. spring tine harrowed Oct. 22. H. harrowed Oct. 30. Drilled and harrowed in wheat at 3 bushels per acre Nov. 10 Crop failed. T. ploughed in wheat June 5. T. cultivated July 13 and Aug. 4. T. thistlebarred Sept. 11.	—	Nov. 10	—	—	—

DATES OF SOWING AND HARVESTING, AND YIELD PER ACRE, ROTHAMSTED, 1937 (*Continued*)

Field	Crop	Variety	Principal Cultivations and Dates	Manuring per acre	Sowing Dates	Cutting Dates	Carting Dates	Yield per acre
Bone's Close	Barley	Plumage Archer	T. cultivated in autumn. T. spring tine harrowed twice April 26. H. harrowed, drilled and harrowed in barley at 3 bushels per acre April 27.	—	April 27	Sept. 23	Oct. 1	4 cwt
Grassland :								
Great Field I	Grazed	Old Pasture	Topped June 17.	—	—	—	—	—
II	Grazed	Ditto	Topped July.	—	—	—	—	—
III	Grazed	Ditto	Topped July 5.	—	—	—	—	—
Little Knott I and II	Grazed	See Report 1931		—	See Report 1931	—	—	—
Great Knott I	Hay after late grazing	Ditto		—	Ditto	June 28	July 8	27 cwt.
II	Hay	Ditto		—	Ditto	June 30	July 8	27 cwt.
West Barnfield I and II	Hay after grazing	Ditto		—	Ditto	June 24	July 5	27 cwt.
Foster's Corner	Grazed	Ditto	Topped June 26.	—	Ditto	—	—	—
Great Harpenden	Grazed	Ditto	Topped June 21.	—	Ditto	—	—	—
Stackyard	Grazed	Ditto	Topped July 6.	—	Ditto	—	—	—
New Zealand	Grazed	Ditto	Topped June 18. Nettles cut Aug. 3.	—	Ditto	—	—	—
Sawyers I	Hay after grazing	Ditto		—	Ditto	June 22	June 29	27 cwt.
II	Hay	Ditto		—	Ditto	June 22	June 29	27 cwt.
III	Grazed	Ditto	Topped June 23.	—	Ditto	—	—	—
Hill Harpenden	Grazed	Old Pasture	Topped June 14.	—	—	—	—	—
Delharding	Grazed	Ditto	T. chain harrowed both ways April 20. Topped June 16. Nettles cut Aug. 3.	—	—	—	—	—
High Field	Grazed	Ditto	T. chain harrowed both ways April 20. Topped July 7.	Half of each plot 10 cwt. basic slag.	—	—	—	—
Appletree	R.A.S.E. experiment Hay	Ditto		—	—	July 1	July 13	30 cwt.

DETAILED RESULTS OF THE EXPERIMENTS 1937

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

CHEMICAL ANALYSES OF MANURES USED IN REPLICATED EXPERIMENTS, 1937

Manures	%N	$\%P_2O_5$	$\%K_2O$
Sulphate of Ammonia	21.0–21.1	—	—
Nitrate of Soda	14.9–15.8	—	—
Nitrochalk	15.5	—	—
Cyanamide	20.7	—	—
Poultry Manure (1)	3.49	3.31	1.64
,, ,, ...	3.34	3.18	1.62
,, ,, ...	4.36	3.98	1.71
,, ,, ...	3.81	3.72	1.76
,, ,, ...	3.75	3.30	1.76
Rape Dust	5.52	1.80	1.03
Soot	2.57, 3.34, 3.98	—	—
Fish Meal	8.04	5.39	1.41
Dung (stored) (2)	0.53	—	—
Dung + straw (stored) (3)	0.79	—	—
Dung (4)	0.45	—	—
Dung (5)	0.60	—	—
Superphosphate	17.5—16.8 Total 15.0—15.8 Water Sol.		$\%P_2O_5$
Sulphate of Potash	49.4		$\%K_2O$
Muriate of Potash	52.0—51.8		$\%K_2O$
Muriate of Potash (high grade)	62.4—62.7		$\%K_2O$

(1) Used for Rothamsted and Woburn Experiments. All other samples of poultry manure used at outside centres.
(2) (3) Used in Rothamsted Potato Experiment, Spring application.
(4) Used in Rothamsted Potato Experiment, Autumn application.
(5) Used in Rothamsted Sugar Beet and Mangold Experiments.

Three Course Rotation

Manures	% Organic Matter	% N	$\%P_2O_5$	$\% K_2O$
Chaffed Straw	82.7	0.52	0.21	1.58
Adco	13.6	0.44	0.25	0.18
Superphosphate..	—	—	17.5(1) 17.6(2) 16.8(2)	—
Sulphate of Ammonia.. ..	—	21.1(1) 21.0(2) 21.1(2)	—	—
Muriate of Potash	—	—	—	52.0(1) 51.8(2)
Sulphate of Potash	—	—	—	49.4
Nitrate of Soda	—	14.9	—	—

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

Four Course Rotation

Manures	% Organic Matter	% N	$\%P_2O_5$	$\% K_2O$
Chaffed Straw	82.7	0.52	0.21	1.58
Dung	18.5	0.63	0.26	0.90
Adco	13.6	0.44	0.25	0.18
Superphosphate	—	—	17.5(1) 17.6(2)	—
Mineral Phosphate (90% through 120 mesh)	—	—	26.0	—
Muriate of Potash	—	—	—	52.0(1) 51.8(2)
Sulphate of Ammonia	—	21.1	—	—

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

Six Course Rotation

Sulphate of Ammonia	21.0 % N
Superphosphate	17.5 % P_2O_5 (Total)
Muriate of Potash	52.0([1]), 51.8([2]) % K_2O

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

Long Period Cultivation Experiment

Cyanamide..	20.7% N
Nitrochalk	15.4% N
Superphosphate	16.8% P_2O_5 (Total)
Muriate of Potash	51.8% K_2O

AVERAGE WHEAT YIELDS OF VARIOUS COUNTRIES

Country	Mean yield per acre, 1927-36 cwt.	Country	Mean yield per acre, 1927-36 cwt.
Great Britain	17.9	Denmark	23.0
England and Wales ..	17.7	Argentine	7.3
Hertfordshire	16.8	Australia	6.1
France	12.0	Canada	7.8
Germany	17.0	United States	7.2
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. 71. Other figures from "International Year Book of Agricultural Statistics," 1929-37.

*Excluding 1931, and 1936.

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, 1937

	Rain.		Drainage through soil.				Temperature (Mean).			
	Total fall 1/1000th Acre Gauge.	No. of Rainy Days (0.01 inch or more) 1/1000th Acre Gauge.	20 ins. deep.	40 ins. deep.	60 ins. deep.	Bright Sun-shine.	Max.	Min.	1 ft. in ground	Grass Min.
1937—	Inches.	No.	Inches.	Inches.	Inches.	Hours.	°F.	°F.	°F.	°F.
Jan. ..	4.714	24	4.348	4.662	4.477	44.4	44.6	35.2	40.1	31.9
Feb. ..	4.282	24	3.437	3.739	3.597	64.4	46.4	36.6	39.8	32.7
Mar. ..	3.557	19	3.107	3.419	3.254	104.5	43.0	32.5	38.2	28.0
April ..	3.023	19	1.544	1.714	1.597	95.3	53.3	40.9	46.5	37.3
May ..	3.777	15	1.800	2.018	1.920	158.3	60.6	45.5	53.0	41.9
June ..	1.831	11	0.328	0.353	0.339	187.6	65.1	49.0	59.4	43.6
July ..	1.779	10	0.000	0.000	0.000	126.1	67.4	53.6	61.2	49.4
Aug. ..	1.985	6	0.848	0.850	0.781	187.1	71.3	54.3	62.3	49.8
Sept. ..	2.786	16	1.040	1.044	0.922	138.7	63.4	47.3	56.5	42.8
Oct. ..	2.647	14	1.608	1.575	1.501	78.3	56.2	44.2	51.1	40.0
Nov. ..	1.804	13	1.299	1.325	1.242	69.3	45.9	36.1	43.2	32.1
Dec. ..	3.207	25	3.036	3.234	3.099	24.1	40.0	31.7	37.8	28.9
Total or Mean	*35.392*	*196*	*22.395*	*23.933*	*22.729*	*1278.1*	*54.8*	*42.2*	*49.1*	*38.2*

RAIN AND DRAINAGE

MONTHLY MEAN FOR 67 HARVEST YEARS, 1870-1—1936-7

	Rain-fall.	Drainage.			Drainage % of Rainfall.			Evaporation.		
		20-in. Gauge.	40-in. Gauge.	60-in. Gauge.	20-in. Gauge.	40-in. Gauge.	60-in. Gauge.	20-in. Gauge.	40-in. Gauge.	60-in. Gauge.
	Inches	Inches	Inches	Inches	%	%	%	Inches	Inches	Inches
Sept. ..	2.427	0.828	0.807	0.746	34.1	33.3	30.7	1.599	1.620	1.681
Oct. ..	3.065	1.721	1.700	1.575	56.2	55.5	51.4	1.344	1.365	1.490
Nov. ..	2.889	2.216	2.274	2.147	76.7	78.7	74.3	0.673	0.615	0.742
Dec. ..	2.812	2.391	2.490	2.381	85.0	88.5	84.7	0.421	0.322	0.431
Jan. ..	2.438	2.008	2.200	2.101	82.4	90.2	86.2	0.430	0.238	0.337
Feb. ..	2.034	1.508	1.626	1.552	74.1	79.9	76.3	0.526	0.408	0.482
Mar. ..	1.984	1.073	1.201	1.137	54.1	60.5	57.3	0.911	0.783	0.847
April ..	2.071	0.684	0.764	0.727	33.0	36.9	35.1	1.387	1.307	1.344
May ..	2.077	0.508	0.576	0.543	24.5	27.7	26.1	1.569	1.501	1.534
June ..	2.235	0.544	0.562	0.539	24.3	25.1	24.1	1.691	1.673	1.696
July ..	2.685	0.701	0.730	0.682	26.1	27.2	25.4	1.984	1.955	2.003
Aug. ..	2.553	0.676	0.690	0.648	26.5	27.0	25.4	1.877	1.863	1.905
Year	*29.270*	*14.858*	*15.620*	*14.778*	*50.8*	*53.4*	*50.5*	*14.412*	*13.650*	*14.492*

https://doi.org/10.23637/ERADOC-1-69

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 (23rd), 1936-7							
1936	Roots (Turnips) ..	cwt.	24.4	9.4	53.8	51.0	112.6	65.3
1937	Barley—							
	Dressed grain ..	bush.	0.6	0.4	2.7	0.5	0.9	1.5
	Total straw ..	cwt.†	3.4	2.1	2.5	4.7	2.7	3.4

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

† Includes straw, cavings and chaff.

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

‡‡ Based on 9 courses.

§ Based on 13 courses.

CULTIVATIONS, ETC.—Ploughed: Nov. 26. Spring tine harrowed: March 30. Harrowed: March 31. Hoed: May 6. Clover sown: May 10. Variety: Montgomery Red. Rolled: May 10 and 17. Hand hoed: June 8 and 9. Seed sown: March 31. Variety: Plumage Archer. Harvested: Sept. 3.

Note.—The crop was very weedy and the straw figures were obtained by sampling for the ratio of grain plus straw to weeds.

https://doi.org/10.23637/ERADOC-1-69

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 ;

W

A	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, 1937

	B2	B3	B4	*Mean*	*Average 81 years, 1856-1936*
Dressed Grain—bushels	8.9	6.7	8.1	*7.9*	*14.3*
Total Grain—cwt.	6.0	4.8	4.8	*5.2*	*8.1*
Weight per bushel—lb.	62.1	61.6	61.4	*61.7*	*58.9*
Total Straw—cwt.	10.6	7.9	9.2	*9.2*	*12.7*

CULTIVATIONS, ETC.—Cropped sections: Ploughed: Oct. 16. Harrowed: Oct. 21 and May 3. Seed sown: Oct. 21. Variety: Red Standard. Harvested: Aug. 20. Fallowed sections: Ploughed: Aug. 24, June 3 and 4. Cultivated: Oct. 5 and June 9. Spring tine harrowed: Mar. 26 and April 26.

MANGOLDS—BARNFIELD, 1937

Roots each year since 1856.

Mangolds each year since 1876.

PRODUCE PER ACRE

	Strip	Strip Manures (Amounts stated are per acre)	1937 Cross Dressings O None	N Nitrate of Soda (550 lb.)	A Sulphate of Ammonia (412 lb.)	AC Sulphate of Ammonia (412 lb.) & Rape Cake	C Rape Cake (2,000 lb.)	55 Year Average, 1876-1936.† Cross Dressings O None	N Nitrate of Soda (550 lb.)	A Sulphate of Ammonia (412 lb.)	AC Sulphate of Ammonia (412 lb.) & Rape Cake	C Rape Cake (2,000 lb.)
			Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
Roots	1	Dung (14 tons)	8.34	16.50	15.84	18.49	16.09	17.57	26.60	22.01	23.73	23.66
	2	Dung, Superphosphate (3½ cwt.), Sulphate of Potash (500 lb.)	9.54	18.41	13.21	14.85	12.97	19.25	27.35	25.12	27.76	26.77
	4	Complete Minerals: Super. and Potash as 2, Sodium Chloride (200 lb.), Sulphate of Magnesia (200 lb.) ..	2.08	(a)11.21** (b)11.71**	8.62	13.18	9.17	4.74	(a)17.98 (b)19.02*	14.82	26.27	21.27
	5	Superphosphate (3½ cwt.)	1.89	12.01	7.07	7.05	6.53	4.55	15.15	6.91	9.46	10.20
	6	Super. (3½ cwt.) Sulphate of Potash (500 lb.)	1.45	9.97	6.20	11.25	7.34	4.14	15.65	13.81	22.52	18.34
	7	Super. (3½ cwt.) Sulphate of Magnesia (200 lb.), and Sodium Chloride (200 lb.)	1.58	9.37	7.41	11.23	7.84	4.89	16.64	15.08	22.26	19.46
	8	No Minerals	1.71	8.34	5.19	5.80	5.37	3.38	10.03	5.51	8.59	9.14
	9	Sodium Chloride (200 lb.), Nit. Soda (550 lb.), Sulphate of Potash (500 lb.) and Sulphate of Magnesia (200 lb.) ..	7.19	—	—	—	—	—	—	—	—	—
Leaves	1	Dung (14 tons)	3.22	5.99	5.55	6.03	4.80	3.10	4.66	4.89	5.22	4.59
	2	Dung, Superphosphate (3½ cwt.), Sulphate of Potash (500 lb.)	4.01	7.15	5.29	5.31	4.40	3.19	5.16	5.43	6.19	4.82
	4	Complete Minerals: Super. and Potash as 2, Sodium Chloride (200 lb.), Sulphate of Magnesia (200 lb.) ..	1.22	(a)4.60 (b)3.96	3.40	3.69	2.42	1.07	(a)3.87 (b)4.13*	2.92	5.28	3.40
	5	Superphosphate (3½ cwt.)	1.06	4.21	2.91	4.02	3.08	1.07	3.20	2.62	3.27	2.87
	6	Super. (3½ cwt.) Sulphate of Potash (500 lb.)	0.97	4.85	3.17	4.67	2.72	0.95	3.08	2.82	5.13	2.92
	7	Super. (3½ cwt.) Sulphate of Magnesia (200 lb.) and Sodium Chloride (200 lb.)	1.07	5.36	3.81	5.80	3.11	1.11	3.36	3.07	5.21	3.40
	8	No Minerals	1.10	4.39	2.86	4.02	3.35	0.98	3.23	2.55	3.29	2.91
	9	Sodium Chloride (200 lb.), Nit. Soda (550 lb.), Sulphate of Potash (500 lb.) and Sulphate of Magnesia (200 lb.) ..	3.57	—	—	—	—	—	—	—	—	—

** From 1904 onwards plot 4N has been divided, 4(a) receiving Superphosphate, Sulphate of Potash, Sulphate of Magnesia, Sodium Chloride and Nitrate of Soda, amounts as above: 4(b) receiving Superphosphate, Calcium Chloride (190 lb.), Potassium Nitrate (570 lb.) and Calcium Nitrate (100 lb.). Nitrogenous manures are applied one-third at time of sowing and two-thirds as top dressing at a later date, except with Rape Cake which all goes on with the seed.

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

* 28 years only, 1904-1936, excluding 1908, 1927, 1930, 1931 and 1935. For this period the average yield of plot 4(a) was 19.23 for roots and 4.02 for leaves.

CULTIVATIONS, ETC.—Ploughed (except plot 9): Nov. 27-Dec. 2. Ploughed in dung: Dec. 1 and 2. Ploughed plot 9: April 8. Springtine harrowed: May 4. Harrowed and rolled: May 8. Hand hoed: June 7 and 8. Horse hoed: June 7, 8, July 6, 7, 15 and 20-23. Singled: July 7-30. Manures applied: May 5-7, Aug. 5 and 6. Seed sown: May 8. Variety: Yellow Globe. Lifted: Nov. 1-11.

HAY—THE PARK GRASS PLOTS, 1937

Plot	Manures since 1905	Yield of Hay (cwt. per acre) Not limed 1st Crop	Not limed 2nd Crop ***	Not limed Total	Limed 1st Crop	Limed 2nd Crop ***	Limed Total	Dry Matter (cwt. per acre) Not limed 1st Crop	Not limed 2nd Crop	Not limed Total	Limed 1st Crop	Limed 2nd Crop	Limed Total
1	Sulphate of ammonia (206 lb.)	17.1	6.4	*23.5*	23.0	6.3	*29.3*	12.1	5.1	*17.2*	17.6	5.0	*22.6*
2	Unmanured	13.1	8.0	*21.1*	16.5	5.0	*21.5*	10.0	6.4	*16.4*	12.8	4.0	*16.8*
3	Unmanured	11.8	6.0	*17.8*	15.6	3.5	*19.1*	8.7	4.8	*13.5*	11.6	2.8	*14.4*
4-1	Superphosphate (3½ cwt.)	16.2	6.7	*22.9*	12.0	4.9	*16.9*	12.3	5.4	*17.7*	9.2	4.0	*13.2*
4-2	As 4-1 and sulphate of ammonia (412 lb.)	32.9	7.5	*40.4*	40.2	8.7	*48.9*	24.3	6.0	*30.3*	28.7	7.0	*35.7*
5-1	Unmanured	17.5	6.6	*24.1*				12.0	5.3	*17.3*			
5-2	Superphosphate (3½ cwt.) and sulphate of potash (500 lb.)	22.4	12.0	*34.4*				15.0	9.6	*24.6*			
6	As 5-2, and sulphate of soda (100 lb.) and sulphate of magnesia (100 lb.)	28.9	11.6	*40.5*				18.7	9.3	*28.0*			
7	As 6	30.1	15.7	*45.8*	39.4	12.5	*51.9*	19.7	12.5	*32.2*	26.6	10.0	*36.6*
8	As 6 without potash	21.1	10.7	*31.8*	21.9	7.2	*29.1*	15.0	8.6	*23.6*	13.9	5.7	*19.6*
9	As 6 and sulphate of ammonia (412 lb.)	47.8	14.3	*62.1*	65.2	15.6	*80.8*	34.2	11.4	*45.6*	39.2	12.5	*51.7*
10	As 8 and sulphate of ammonia (412 lb.)	34.5	9.8	*44.3*	45.9	14.2	*60.1*	22.3	7.8	*30.1*	31.6	11.4	*43.0*
11-1	As 6 and sulphate of ammonia (618 lb.)	41.0	25.6	*66.6*	58.6	19.7	*78.3*	30.5	20.5	*51.0*	34.2	15.8	*50.0*
11-2	As 11-1 and silicate of soda (3½ cwt.)	47.5	24.7	*72.2*	61.9	19.4	*81.3*	34.6	19.7	*54.3*	36.6	15.5	*52.1*
12	Unmanured	12.5	17.8	*30.3*				7.8	14.2	*22.0*			
13	Dung (14 tons) in 1905, fish guano (6 cwt.) in 1907 and every fourth year	51.6	18.0	*69.6*	47.2	15.8	*63.0*	29.6	14.4	*44.0*	26.7	12.6	*39.3*
14	As 6 and nitrate of soda (550 lb.)	43.7	18.2	*61.9*	47.4*	11.3*	*58.7*	32.2	14.6	*46.8*	34.4	9.0	*43.4*
					42.9**	5.8**	*48·7*				26.8	4.7	*31.5*
15	As 6	24.5	13.4	*37.9*	35.6	9.2	*44.8*	19.0	10.7	*29.7*	27.5	7.3	*34.8*
16	As 6 and nitrate of soda (275 lb.)	37.8	16.4	*54.2*	39.7	12.1	*51.8*	26.9	13.1	*40.0*	29.4	9.7	*39.1*
17	Nitrate of soda (275 lb.)	20.6	9.9	*30.5*	29.0	3.8	*32.8*	13.9	7.9	*21.8*	21.1	3.1	*24.2*
18	As 6 (without superphosphate) and sulphate of ammonia (412 lb.)	17.2	9.9	*27.1*	26.2†	6.2†	*32.4*	12.6	7.9	*20.5*	16.8	5.0	*21.8*
					31.0††	9.1††	*40.1*				19.7	7.3	*27.0*
19	Dung every fourth year	35.2	20.0	*55.2*	35.7§	8.0§	*43.7*	22.1	16.0	*38.1*	22.9	6.4	*29.3*
					33.4§§	15.4§§	*48.8*				21.1	12.3	*33.4*
20	As 19 and superphosphate (200 lb.), sulphate of potash (100 lb.) and nitrate of soda (168 lb.) every intervening year	40.5	19.5	*60.0*	33.0‡	10.7‡	*43.7*	26.8	15.6	*42.4*	21.7	8.6	*30.3*
					37.1§§	16.1§§	*53.2*				24.1	12.9	*37.0*

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

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

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

Cultivations, etc.—Harrowed: Mar. 5. Dung applied: Mar. 19 and 20. Rolled: April 28. Manures applied: Mar. 22-24, April 8, 9 and May 13, cut 1st crop, June 10-12; 2nd crop, Oct. 15, 16 and 18.

For a complete description of the manures since 1856, see the 1935 Report, p. 151.

PARK GRASS PLOTS

BOTANICAL COMPOSITION PER CENT. 1937 (*1st Crop*)

Plot	Manuring	Liming	Gramineae	Leguminosae	Other Orders	" Other Orders " consist largely of
4	Unmanured	Limed	54.84	14.93	30.23	*Scabiosa arvensis*, *Plantago lanceolata*
		Unlimed	56.96	7.69	35.35	*Plantago lanceolata*, *Poterium sanguisorba*
7	Complete Mineral Manure	Limed	74.23	9.60	16.17	*Rumex acetosa*
		Unlimed	58.39	20.55	21.06	*Rumex acetosa*
8	Mineral Manure (without Potash)	Limed	69.39	13.99	16.62	*Plantago lanceolata*
		Unlimed	57.56	14.57	27.87	*Plantago lanceolata*
9	Complete Mineral Manure and double Amm. Salts	Limed	98.25	—	1.75	—
		Unlimed	100.00	—	—	—
10	Mineral Manure (without Potash) and double Amm. Salts	Limed	96.93	0.15	2.92	*Rumex acetosa*
		Unlimed	99.89	—	0.11	—
14	Complete Mineral Manure and double Nitrate of Soda	Limed (sun)	84.22	0.50	15.28	*Anthriscus sylvestris*
		Limed (shade)	94.33	1.73	3.94	—
		Unlimed	92.63	0.29	7.08	*Anthriscus sylvestris*
18	Mineral Manure (without Super) and double Sulphate Amm. 1905 and since.	L.6,788 lb.	72.00	0.40	27.60	*Taraxacum vulgare*
		L.3,951 lb.	80.99	0.15	18.86	*Taraxacum vulgare*
		Unlimed	99.67	—	0.33	—
19	Farmyard Dung in 1905 and every fourth year since (omitted 1917)	L.3,150 lb.	85.28	5.63	9.09	—
		L.570 lb.	75.61	9.90	14.49	—
		Unlimed	84.44	5.33	10.23	—
20	Farmyard Dung in 1905 and every fourth year since (omitted 1917); each intervening year Sulphate of Potash, Super., and Nitrate of Soda	L.2772 lb.	Lost	by accid	ent	—
		L.570 lb.	87.47	2.14	10.39	—
		Unlimed	Lost	by accid	ent	—

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PARK GRASS PLOTS

BOTANICAL COMPOSITION PER CENT. 1934 (*1st Crop*)

Plot	Manuring	Liming	Gram-ineae	Legum-inosae	Other Orders	" Other Orders " consist largely of
3	Unmanured	Limed	53.01	5.71	41.28	*Poterium sanguisorba*
		Unlimed	57.37	5.33	37.30	—
5[1]	Unmanured after Ammonium Salts	Unlimed	70.59	4.41	25.00	*Centaurea nigra* *Plantago lanceolata*
5[2]	Mineral Manure after Ammonium Salts	Unlimed	56.03	35.48	8.49	*Achillea millefolium*
6	Complete Mineral Manure after Ammonium Salts	Unlimed	41.00	40.47	18.53	*Heracleum sphondylium* —
7	Complete Mineral Manure	Limed	42.17	41.16	16.67	*Centaurea nigra* *Heracleum sphondylium*
		Unlimed	46.48	37.12	16.40	—
9	Complete Mineral Manure and double Amm. Salts	Limed	97.59	0.64	1.77	*Heracleum sphondylium*
		Unlimed	100.00	—	—	
14	Complete Mineral Manure and double Nitrate of Soda	Limed (sun)	96.40	1.51	2.09	*Anthriscus sylvestris*
		Limed (shade)	95.52	2.95	1.53	*Heracleum sphondylium*
		Unlimed	96.66	1.35	1.99	*Anthriscus sylvestris*
18	Mineral Manure (without Super) and double Sulphate Amm. 1905 and since	L.6,788 lb.	71.96	—	28.04	*Taraxacum vulgare*
		L.3,951 lb.	72.67	0.21	27.12	*Taraxacum vulgare*
		Unlimed	98.88	—	1.12	*Rumex acetosa*
19	Farmyard Dung in 1905 and every fourth year since (omitted 1917)	L.3,150 lb.	90.67	1.34	7.99	*Centaurea nigra*
		L.570 lb.	89.70	2.40	7.90	*Achillea millefolium*
		Unlimed	84.63	3.74	11.63	—
20	Farmyard Dung in 1905 and every fourth year since (omitted 1917); each intervening year Sulphate of Potash, Super., and Nitrate of Soda	L.2772 lb.	80.05	8.25	11.70	—
		L.570 lb.	94.57	0.64	4.79	*Achillea millefolium*
		Unlimed	90.81	2.49	6.70	*Achillea millefolium*

These figures were not available in time for the 1934 Report and are included here for the sake of completeness.

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PARK GRASS PLOTS

BOTANICAL COMPOSITION PER CENT. 1937 (*1st Crop*)

	Unlimed (U); Limed (L) Plots	3U	3L	7U	7L	8U	8L	9U	9L	10U	10L	14U	Sun 14L	Shade 14L
	Gramineae.													
1.	Agrostis vulgaris	11.76	0.96	11.69	0.29	4.36	1.14	0.50	0.27	10.98	0.64	—	—	0.69
3.	Alopecurus pratensis	1.64	5.25	1.44	17.05	0.49	1.76	0.32	49.93	1.02	61.84	44.76	18.73	21.66
4.	Anthoxanthum odoratum	10.25	0.67	4.78	0.05	7.32	1.24	0.19	3.18	32.96	2.33	—	—	0.61
5.	Arrhenatherum avenaceum ..	0.46	0.44	2.89	17.44	10.28	25.60	—	30.27	2.37	6.49	39.36	44.90	16.21
6.	Avena flavescens	0.39	2.74	1.26	2.92	1.97	4.80	—	—	—	—	—	0.54	2.34
7.	Avena pubescens	4.20	16.48	1.51	3.07	4.93	10.84	—	—	—	—	0.04	0.41	10.05
8.	Briza media	2.96	4.66	—	—	0.21	0.83	—	—	—	—	—	—	—
9.	Bromus mollis	—	—	—	0.15	—	—	—	—	—	—	—	0.05	0.52
10.	Cynosurus cristatus	0.13	0.07	—	—	—	—	—	—	—	—	—	—	—
11.	Dactylis glomerata	5.25	4.51	16.34	17.00	1.34	7.23	—	9.40	0.11	0.20	3.23	3.13	1.47
12.	Festuca ovina	14.45	8.06	6.98	1.70	10.42	4.90	—	1.16	1.08	19.92	—	2.54	31.37
13.	Festuca pratensis	—	—	—	—	—	0.83	—	—	—	—	—	—	—
14.	Holcus lanatus	5.45	5.32	10.43	0.93	14.92	3.98	98.93	2.78	51.37	0.05	0.04	—	0.17
15.	Lolium perenne	—	—	—	—	—	0.62	—	—	—	—	—	—	0.13
16.	Poa pratensis	—	2.66	0.88	1.46	0.71	1.55	—	—	—	5.45	0.50	0.59	2.60
17.	Poa trivialis	—	3.03	0.19	12.18	0.63	4.08	0.06	1.25	—	—	4.69	13.33	6.50
	Leguminosae													
1.	Lathyrus pratensis	0.92	1.11	11.19	2.05	0.42	0.21	—	—	—	0.15	0.29	0.50	1.34
2.	Lotus corniculatus	5.25	9.90	1.75	—	3.94	2.99	—	—	—	—	—	—	—
3.	Ononis arvensis	—	—	—	—	—	—	—	—	—	—	—	—	—
4.	Trifolium pratense	1.44	3.92	7.17	3.80	9.99	10.74	—	—	—	—	—	—	—
5.	Trifolium repens	0.07	—	0.44	3.75	0.21	0.05	—	—	—	—	—	—	0.39

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PARK GRASS PLOTS

BOTANICAL COMPOSITION PER CENT. 1937 (*1st Crop*)

(*Continued.*)

No.	Unlimed (U); Limed (L) — Plots	3U	3L	7U	7L	8U	8L	9U	9L	10U	10L	14U	Sun 14L	Shade 14L
	Other Orders													
1. 2.	Ranunculus acris Ranunculus bulbosus	0.33	4.14	0.88	3.02	3.66	2.68	—	—	—	—	—	—	0.09
4.	Cerastium vulgatum	0.07	0.22	—	—	0.14	0.36	—	—	—	—	—	—	—
5.	Stellaria graminea	0.13	—	0.06	—	0.14	—	—	—	—	—	—	—	—
6.	Linum catharticum	—	0.30	—	—	—	—	—	—	—	—	—	—	—
7.	Agrimonia eupatoria	0.07	0.07	—	—	—	0.36	—	—	—	—	—	—	—
11.	Poterium sanguisorba	8.02	5.03	—	—	—	—	—	—	—	—	—	—	—
13.	Anthriscus sylvestris	—	—	—	0.05	—	—	—	0.45	—	—	4.11	13.88	3.03
14.	Conopodium denudatum	2.50	0.44	3.14	0.29	1.27	0.15	—	—	—	—	—	—	0.13
15.	Heracleum sphondylium	—	—	4.52	3.60	—	—	—	0.36	—	—	—	—	—
16.	Pimpinella saxifraga	0.26	0.22	—	—	0.21	0.21	—	—	—	—	—	—	—
17.	Galium verum	—	—	0.13	—	0.28	—	—	—	—	—	—	—	—
18.	Scabiosa arvensis	5.45	7.32	—	—	3.52	3.10	—	—	—	—	—	—	—
19.	Achillea millefolium	0.92	0.30	1.01	0.19	1.34	0.26	—	—	—	—	—	—	—
20.	Centaurea nigra	1.84	1.18	2.14	0.05	2.04	1.96	—	—	—	—	—	—	—
22.	Hieraceum pilosella	—	0.07	—	—	—	—	—	—	—	—	—	—	—
24.	Leontodon hispidus	2.50	2.29	—	—	0.84	0.10	—	—	—	—	—	—	—
26.	Taraxacum vulgare	0.07	0.15	—	3.99	0.28	0.10	—	0.23	—	—	0.34	0.50	0.31
27.	Tragopogon pratensis	0.20	—	—	0.10	—	—	—	—	—	—	—	—	—
29.	Plantago lanceolata	8.80	6.36	2.01	0.49	10.13	4.80	—	—	—	—	—	—	—
30.	Veronica chamaedrys	0.33	0.59	0.13	0.24	0.28	0.57	—	—	—	—	—	—	—
31.	Ajuga reptans	0.13	—	—	—	—	—	—	—	—	—	—	—	—
32	Prunella vulgaris	0.20	0.07	—	—	—	—	—	—	—	—	—	—	—
34.	Rumex acetosa	1.45	0.37	6.66	4.14	2.89	1.70	—	0.72	0.11	2.93	2.64	0.90	0.39
35.	Luzula campestris	1.12	1.03	0.38	—	0.84	0.26	—	—	—	—	—	—	—
36.	Carex praecox	0.99	0.07	—	—	—	—	—	—	—	—	—	—	—

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WHEAT—BROADBALK FIELD, 1937

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	III	IV	V	*Mean*	I	III	IV	V	*Mean*	
2A	Farmyard Manure (14 tons)	(7.8)	(14.7)	(15.8)	(14.5)	*13.2*	(10.9)	(9.0)	(9.7)	(8.9)	*9.6*	*16.3***
2B	Farmyard Manure (14 tons)	17.7	(14.5)	17.4	(15.0)	*16.2*	10.9	(8.9)	10.6	(9.2)	*9.9*	*19.4*
3	Unmanured since 1839	7.6	7.5	(9.3)	(4.3)	*7.2*	5.4	5.2	(6.7)	(3.1)	*5.1*	*6.7*
5	Complete Mineral Manure§§	(11.9)	7.3	(6.3)	(6.6)	*8.0*	(8.6)	5.6	(4.6)	(4.8)	*5.9*	*7.8*
6	As 5, and 206 lb. Sulphate of Ammonia	(22.0)	(10.3)	(9.8)	(12.1)	*13.6*	(13.4)	(6.3)	(6.0)	(7.4)	*8.3*	*12.5*
7	As 5, and 412 lb. Sulphate of Ammonia	(17.6)	16.8	12.7	13.3	*15.1*	(11.0)	10.4	7.8	8.5	*9.4*	*17.6*
8	As 5, and 618 lb. Sulphate of Ammonia	22.5	(21.6)	20.4	18.3	*20.7*	13.1	(13.0)	12.1	11.5	*12.4*	*20.1*
9	As 5, and 275 lb. Nitrate of Soda	19.2	(16.2)	12.4	(13.9)	*15.4*	11.3	(9.7)	7.6	(8.3)	*9.2*	*13.9*††
10	412 lb. Sulphate of Ammonia	21.2	(21.4)	15.3	(18.5)	*19.1*	12.5	(12.8)	9.2	(11.1)	*11.4*	*10.9*
11	As 10, and Superphosphate (3½ cwt.)											
12	As 10, and Super. (3½ cwt.) and Sulph. Soda (366 lb.)	23.7	(19.0)	(17.2)	15.0	*18.7*	13.5	(11.4)	(10.3)	9.2	*11.1*	*12.3*
13	As 10, and Super. (3½ cwt.) and Sulph. Potash (200 lb.)	19.5	(19.2)	17.7	16.3	*18.2*	11.5	(11.3)	10.2	9.5	*10.6*	*15.7*
14	As 10, and Super. (3½ cwt.) and Sulph. Magnesia (280 lb.)	21.8	(14.9)	(14.6)	14.6	*16.5*	13.0	(9.1)	(8.9)	9.0	*10.0*	*17.0*
15	As 5, and 412 lb. Sulphate Amm. all applied in	18.4	18.6	17.8	21.3	*19.0*	11.4	11.1	10.4	12.4	*11.3*	*15.5*
	Autumn	18.8	(11.2)	8.4	11.3	*12.4*	11.8	(7.1)	5.3	7.2	*7.8*	*16.1*
16	As 5, and 550 lb. Nitrate of Soda	(23.6)	23.0	25.4	23.5	*23.9*	(13.7)	13.4	14.5	13.7	*13.8*	*17.8*††
17	Minerals alone as 5 or 412 lb. Sulphate of Ammonia	M11.5	(6.2)	7.1	8.0	*8.2*	7.8	(4.1)	4.6	5.3	*5.4*	M *8.1**
18	alone in alternate years	A(22.6)	20.8	20.1	21.1	*21.2*	(13.4)	12.4	11.8	12.6	*12.6*	A*16.1*
19	Rape Cake (1,889 lb.)	(18.4)	(17.2)	19.1	15.4	*17.5*	(10.8)	(10.1)	11.3	9.0	*10.3*	*12.6*‡
20	As 7, without Super	(24.3)	—	—	—	*24.3*	(15.2)	—	—	—	*15.2*	*10.3*§

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

For notes, see next page.

Season	I	II	IV	IV	V
1925-26	F	F	F	C	C
1926-27	F	F	F	C	C
1927-28	C	C	F	F	F
1928-29	C	C	F	F	F
1929-30	C	C	C	C	C

Season	I	II	III	IV	V
1930-31 and 5-6	F	C	C	C	C
1931-32 and 6-7	C	F	C	C	C
1932-33 and 7-8	C	C	C	C	F
1933-34 and 8-9	C	C	C	F	C
1934-35 and 9-40	C	C	F	C	C

The grain from a number of plots was severely damaged by rats in the barn before threshing. After examination of the grain-straw ratios of previous years, it was considered that the grain yields for these plots could reasonably be estimated from the grain-straw ratios of comparable undamaged plots; these estimates are enclosed in brackets.

WHEAT—BROADBALK FIELD, 1937

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	III	IV	V	*Mean*	I	III	IV	V	*Mean*	
2A	Farmyard Manure (14 tons)	61.0	60.0	60.8	62.0	*61.0*	45.3	37.4	40.5	37.1	*40.1*	*32.1***
2B	Farmyard Manure (14 tons)	61.2	62.0	60.8	60.4	*61.1*	47.1	37.1	41.8	38.4	*41.1*	*34.2*
3	Unmanured since 1839	63.4	61.0	61.2	61.6	*61.8*	29.3	16.2	23.0	10.7	*19.8*	*9.8*
5	Complete Mineral Manure§§	63.2	62.2	62.0	61.2	*62.2*	29.5	20.8	15.9	16.6	*20.7*	*11.5*
6	As 5, and 206 lb. Sulphate of Ammonia	—	62.6	61.6	61.8	*62.0*	53.5	25.3	24.1	29.5	*33.1*	*20.3*
7	As 5, and 412 lb. Sulphate of Ammonia	59.8	61.5	59.2	59.0	*59.9*	58.1	49.7	48.6	42.5	*49.7*	*32.1*
8	As 5, and 618 lb. Sulphate of Ammonia	59.1	58.9	58.7	58.4	*58.8*	62.9	64.9	59.5	56.7	*61.0*	*39.8*
9	As 5, and 275 lb. Nitrate of Soda	61.3	—	61.2	60.4	*61.0*	42.6	37.2	31.8	31.9	*35.9*	*24.6*††
10	412 lb. Sulphate of Ammonia	59.9	61.2	60.5	60.4	*60.5*	41.7	45.6	36.5	39.8	*40.9*	*17.8*
11	As 10, and Superphosphate (3½ cwt.)	58.8	61.0	59.3	58.9	*59.5*	48.2	40.6	36.7	34.6	*40.0*	*21.4*
12	As 10, and Super. (3½ cwt.) and Sulph. Soda (366 lb.)	59.4	60.4	58.2	58.5	*59.1*	46.6	45.1	40.2	38.5	*42.6*	*26.8*
13	As 10, and Super. (3½ cwt.) and Sulph. Potash (200 lb.)	60.0	61.3	60.2	60.2	*60.4*	55.9	45.7	44.7	50.3	*49.2*	*30.6*
14	As 10, and Super. (3½ cwt.) and Sulph. Magnesia (280 lb.)	59.4	61.1	58.4	59.4	*59.6*	48.9	56.4	40.5	42.7	*47.1*	*26.8*
15	As 5, and 412 lb. Sulphate Amm. all applied in Autumn	62.0	61.8	60.2	60.1	*61.0*	40.3	26.2	24.1	24.3	*28.7*	*28.2*
16	As 5, and 550 lb. Nitrate of Soda	59.6	59.4	58.5	57.9	*58.8*	52.6	59.5	52.2	50.3	*53.6*	*35.2*††
17	Minerals alone as 5 or 412 lb. Sulphate of Ammonia	M64.1	61.2	60.0	60.4	*61.4*	31.9	16.3	19.0	20.2	*21.8*	M*12.3**
18	alone in alternate years	A58.8	60.9	58.9	59.8	*59.6*	51.7	47.3	49.9	45.5	*48.6*	A*28.1*
19	Rape Cake (1,889 lb.)	62.2	60.6	61.1	60.6	*61.1*	32.8	30.6	34.0	27.2	*31.2*	*22.0*‡
20	As 7, without Super.	60.0	—	—	—	*60.0*	60.9	—	—	—	*60.9*	*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: Sept. 15-24. Dung applied: Sept. 23. Cultivated: Oct. 8. Tractor spring tine harrowed: Oct. 15. Tractor disc harrowed dung plots: Oct. 16. Spring tine harrowed: Oct. 17. Harrowed: Oct. 20-21. Manures applied: Oct. 6, 7, April 1, 2 and May 10. Seed sown: Oct. 20-21. Variety: Red Standard. Harvested: Aug. 9-11. Fallowed section: Ploughed: Sept. 15-24. Cultivated: Oct. 8. Tractor spring tine harrowed: Oct. 15. Tractor disc harrowed: Oct. 16. Tractor rolled and harrowed, then spring tine harrowed: Oct. 17. Spring tine harrowed: April 2 and 27. Ploughed: May 10. Cultivated: May 27 and Aug. 6. Nitrate of soda applied to plot, 16: May 10.

BARLEY—HOOS FIELD, 1937

Plot	Manuring (amounts stated are per acre).	Dressed Grain bushels per acre‖ 1937	Dressed Grain bushels per acre‖ *Average 1852-1928*	Total Grain cwt. per acre	Bushel weight in lb.	Total Straw cwt. per acre† 1937	Total Straw cwt. per acre† *Average 1852-1928*
1O	Unmanured	4.0	*13.4*	2.3	51.2	6.1	*7.8*
2O	Superphosphate (3½ cwt.)	5.5	*19.0*	3.0	52.1	7.1	*9.8*
3O	Alkali Salts (see below)	5.6	*14.3*	3.1	50.7	8.3	*8.7*
4O	Super. and Alkali Salts	8.8	*19.0*	5.2	51.4	16.4	*11.2*
5O	Super. and Potash (200 lb.) ..	5.3	*15.5*	2.9	50.8	4.9	*9.4*
1A	As 1O and sulphate of ammonia (206 lb.).	9.2	*23.7*	4.6	50.6	11.0	*13.7*
2A	As 2O and sulphate of ammonia (206 lb.).	16.8	*35.8*	8.4	52.4	14.0	*20.4*
3A	As 3O and sulphate of ammonia (206 lb.).	12.3	*25.8*	6.2	52.3	13.0	*16.0*
4A	As 4O and sulphate of ammonia (206 lb.).	20.4	*39.3*	9.5	50.0	20.2	*23.6*
5A	As 5O and sulphate of ammonia (206 lb.).	18.9	*33.8*	9.7	53.8	17.3	*21.7*
1AA	As 1O and nitrate of soda (275 lb.).	12.5	*24.3**	6.7	53.5	16.9	*15.4**
2AA	As 2O and nitrate of soda (275 lb.).	23.7	*38.8**	12.0	54.2	19.1	*23.1**
3AA	As 3O and nitrate of soda (275 lb.).	10.6	*24.5**	5.6	53.2	12.4	*16.6**
4AA	As 4O and nitrate of soda (275 lb.).	18.9	*37.7**	9.7	53.7	17.6	*23.6**
1AAS	As 1AA and silicate of soda (400 lb.).	12.7	*30.2**	6.6	53.8	16.3	*18.2**
2AAS	As 2AA and silicate of soda (400 lb.).	21.6	*39.7**	10.9	54.3	18.7	*23.9**
3AAS	As 3AA and silicate of soda (400 lb.).	12.6	*31.2**	6.4	52.9	14.7	*19.9**
4AAS	As 4AA and silicate of soda (400 lb.).	17.8	*39.9**	10.0	53.2	17.8	*25.4**
1C	As 1O and rape cake (1,000 lb.)	15.6	*35.5*	7.9	52.8	14.7	*20.6*
2C	As 2O and rape cake (1,000 lb.)	20.4	*38.1*	10.0	52.5	17.2	*22.0*
3C	As 3O and rape cake (1,000 lb.)	11.7	*33.7*	5.7	51.0	11.2	*20.4*
4C	As 4O and rape cake (1,000 lb.)	19.0	*37.5*	9.2	51.3	16.0	*22.6*
7-1	Dung (14 tons) 1852-71 : afterwards unmanured	6.0	*22.5*‡	3.6	52.6	13.3	*13.5*‡
7-2	Farmyard Manure (14 tons) ..	31.1	*44.6*	15.2	52.0	31.7	*28.1*
6-1	Unmanured	3.2	*14.7*	1.8	52.4	5.2	*8.6*
6-2	Ashes from Laboratory furnace 1852-1933 : afterwards unmanured	3.4	*15.7*	1.9	52.4	5.4	*9.3*
1N	Nitrate of Soda (275 lb.)	8.5	*28.7*§	4.5	52.4	10.9	*17.8*§
2N	Nitrate of Soda (550 lb., 1852-7, afterwards 275 lb.)	12.1	*31.7*§§	6.2	52.6	14.5	*20.0*§§

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

‖ 1 cwt. = 2.15 bushels. In 1912 and 1933 all plots were fallowed.

† Total straw includes straw, cavings and chaff.

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

CULTIVATIONS, ETC.—Shallow ploughed : Sept. 11 and 12. Dung applied : Dec. 3. Ploughed : Dec. 4-21. Springtine harrowed : Mar. 30. Cultivated : Mar. 31. Harrowed and rolled : April 1. Harrowed : April 12. Rolled : May 18. Hand weeded : June 4 and 5. Manures applied : Mar. 25, 26 and April 7. Seed sown : April 7 and 12. Variety : Plumage Archer. Harvested : Sept. 4.

FOUR COURSE ROTATION EXPERIMENT, ROTHAMSTED

RESIDUAL VALUES OF ORGANIC AND PHOSPHATIC FERTILISERS

For details, see 1932 Report, p. 127

MANURES APPLIED, SEASON 1936-7

Treatment	Organic Fertilisers (cwt. per acre)				Additional Artificial Fertilisers (cwt. per acre)		
	Organic Matter	N	P_2O_5	K_2O	N. as S. of A.	P_2O_5 as Super.	K_2O as Mur. of Pot.
1	50 (as F.Y.M.)	1.706	0.704	2.465	0.094	0.496	0.535
2	50 (as Adco)	1.615	0.918	0.661	0.185	0.282	2.339
3	133.50 (as straw)	0.839	0.339	2.550	0.961	0.861	0.450
4			None		0.36	1.2	0.6
5			None		0.36	1.2*	0.6

* As mineral phosphate.

CULTIVATIONS, ETC.

	Barley	Ryegrass	Potatoes	Wheat
Variety	Plumage Archer	Western Wolths	Ally	Yeoman
Date of Sowing ..	March 30	Oct. 3	April 30	Oct. 22
Manures applied—				
Lime	Oct. 9			
Dung, Adco, and accompanying artificials ..	Dec. 22	Sept. 21-22	Dec. 22	Sept. 22
Straw	Dec. 24-30	Sept. 23-25	Dec. 31-Jan. 7	Oct. 2
Artificials to straw	Dec. 24-30, Feb. 2, March 25	Sept. 23-25, Dec. 3, April 9	Dec. 31-Jan. 7, Feb. 2, April 30	Oct. 2, Dec. 3, April 7
Treatments 4 and 5	March 25	Oct. 1	April 30	Oct. 8
Harvested	Aug. 30	June 14	Oct. 7	Aug. 11-12
Previous crop ..	Potatoes	Barley	Wheat	Ryegrass
Cultivations—				
Ploughed ..	Dec. 24-30	Sept. 23-25	Dec. 31-Jan. 7	Oct. 2
Harrowed ..	March 26, 30	Oct. 1, 2, 5	April 2, 13, 24, 26 May 10	Oct. 14-17, 22 May 4
Rolled	March 30	Oct. 1, 2, 5, April 26	April 26, May 10	Oct. 17
Hoed				June 4
Ridged			April 27, 29, May 22, June 18, July 14	
Grubbed ..			June 10, July 12	

PLAN AND YIELDS

Barley—AB, plots 1-25
Yields in lb., grain above, straw below

N.W.

5 76.3 85.7 V	2 37.5 45.0 III	1 58.7 80.8 I	3 30.4 73.6 IV	4 59.6 74.9 II
5 55.9 68.1 II	1 30.8 53.7 IV	3 39.0 54.5 III	4 62.4 80.1 V	2 50.8 71.2 I
3 40.2 46.8 II	2 25.9 44.1 V	5 53.0 78.0 IV	4 63.6 77.9 I	1 36.4 58.1 III
1 36.9 45.6 II	3 44.1 37.4 V	4 59.8 72.7 III	5 47.4 74.1 I	2 32.7 54.3 IV
4 58.7 64.8 IV	1 34.0 49.0 V	5 43.8 64.2 III	3 44.0 59.5 I	2 37.2 58.8 II

Ryegrass—AR, plots 26-50
Yields in lb., hay

N.W.

3 71.0 II	2 62.5 III	5 116.2 IV	4 116.1 I	1 53.4 V
4 138.8 III	2 86.4 I	1 79.2 II	5 118.4 V	3 64.1 IV
1 122.7 I	4 122.2 IV	3 72.5 V	5 126.7 III	2 73.0 II
4 131.6 V	5 124.2 II	3 193.7 I	2 67.3 IV	1 71.4 III
2 64.5 V	4 118.6 II	3 82.1 III	1 61.0 IV	5 99.8 I

Potatoes—AP, plots 51-75
Yields in lb.

N.W.

3 145 III	4 144 V	1 136 IV	2 110 I	5 124 II
3 156 IV	4 192 II	5 139 III	2 91 V	1 154 I
2 138 III	4 166 IV	3 123 II	1 96 V	5 132 I
5 141 IV	1 128 III	3 111 V	4 189 I	2 81 II
4 174 III	2 112 IV	1 141 II	5 125 V	3 145 I

Wheat—AW, plots 76-100
Yields in lb., grain above, straw below

N.W.

4 33.2 52.8 II	2 28.3 45.7 III	5 32.7 62.3 I	3 22.9 48.6 IV	1 24.8 44.7 V
5 40.1 70.4 IV	2 26.3 46.2 V	1 26.7 56.6 II	4 30.1 65.9 I	3 30.9 61.6 III
2 33.9 60.1 I	1 24.8 46.2 III	5 34.5 65.5 V	4 29.0 61.5 IV	3 29.3 56.2 II
2 29.0 52.0 II	4 31.1 62.4 V	1 25.0 45.5 IV	5 29.8 63.7 III	3 33.3 97.7 I
5 36.6 72.9 II	2 27.2 47.3 IV	3 25.0 48.5 V	1 31.0 74.0 I	4 33.0 74.0 III

SUMMARY OF RESULTS, 1937

Manure	Year of Cycle	Wheat cwt. per acre Grain	Wheat cwt. per acre Straw	Potatoes tons per acre	Barley cwt. per acre Grain	Barley cwt. per acre Straw	Ryegrass cwt. per acre dry matter
Manure as F.Y.M.	I	11.9	28.3	2.81	21.5	29.6	25.4
	II	10.2	21.6	2.58	13.5	16.7	15.8
	III	9.5	17.7	2.34	13.3	21.3	15.5
	IV	9.6	17.4	2.49	11.3	19.7	13.5
	V	9.5	17.1	1.75	12.5	18.0	11.8
Manure as Adco	I	13.0	23.0	2.02	18.6	26.1	18.9
	II	11.1	19.9	1.48	13.6	21.6	15.6
	III	10.8	17.5	2.54	13.7	16.5	12.5
	IV	10.4	18.1	2.06	12.0	19.9	13.8
	V	10.1	17.7	1.67	9.5	16.2	17.9
Manure as Straw	I	12.7	37.4	2.66	16.1	21.8	38.8
	II	11.2	21.5	2.26	14.7	17.2	15.4
	III	11.8	23.6	2.66	14.3	20.0	17.6
	IV	8.8	18.6	2.85	11.1	27.0	16.3
	V	9.6	18.5	2.04	16.2	13.7	14.7
Super.	I	11.5	25.2	3.46	23.3	28.6	24.5
	II	12.7	20.2	3.52	21.8	27.5	26.2
	III	12.6	28.3	3.19	21.9	26.6	29.9
	IV	11.1	23.5	3.05	21.5	23.8	26.2
	V	11.9	23.9	2.65	22.9	29.4	28.8
Rock Phosphate	I	12.5	23.8	2.42	17.4	27.2	22.3
	II	14.0	27.9	2.27	20.5	25.0	27.0
	III	11.4	24.4	2.55	16.1	23.5	26.1
	IV	15.3	26.9	2.58	19.4	28.6	24.4
	V	13.2	25.0	2.30	28.0	31.4	23.5

SIX COURSE ROTATION EXPERIMENT,

SEASONAL EFFECTS OF N, P_2O_5 AND K_2O
(For details see 1932 Report, p. 131)

CULTIVATIONS, Etc.—ROTHAMSTED

	Sugar Beet	Barley	Clover Hay	Wheat	Potatoes	Rye
Variety	Kuhn	Plumage Archer	Montgomery Red	Yeoman	Ally	
Date of sowing	May 3	March 30	May 1	Oct. 22	April 30	Oct. 29
Manures applied	May 1	March 25	Nov. 9, April 8	Oct. 8, April 1	April 27	Oct. 29, April 1
Lime applied		March 25				Oct. 9
Harvested	Nov. 15	Aug. 12	June 14	Aug. 11	Oct. 6	Aug. 3
Previous crop	Rye	Sugar Beet	Barley	Clover	Wheat	Potatoes
Cultivations—						
Ploughed	Sept. 9, Dec. 11	Dec. 10-12		July 29, Sept. 5	Sept. 11, April 2	Oct. 27
Harrowed	Sept. 12,14, April 13,23, 26, 30, May 1	Mar. 26, 30 April 30	May 2	Oct. 14, 15, 22, April 26	Oct. 19, April 13,14, 23-26, May 10	Oct. 29
Rolled	Sept. 12, April 30, May 1, 4	March 30, April 30	May 2	April 30	April 26, May 10	Oct. 29
Singled	July 16, 17					
Hoed	May 31, July 21, Aug. 7, 13, 16, Sept. 2,3				Aug. 18	
Ridged					April 26,27, May 25, June 18, July 27	
Grubbed					June 9, July 26	

CULTIVATIONS, Etc.—WOBURN

	Sugar Beet	Barley	Clover Hay	Wheat	Potatoes	Rye
Variety	Kuhn	Plumage Archer	Montgomery Red	Yeoman	Ally	
Date of sowing	April 29	March 23	April 16	Oct. 30	April 8	Nov. 2
Manures applied	April 29	March 23	Oct. 30, April 14	Oct. 30, April 14	April 8	Oct. 4, April 14
Lime applied		Feb. 18				Nov. 2
Harvested	Oct. 7, 8	Aug. 7	June 30	Aug. 9	Sept. 15	July 26
Previous crop	Rye	Sugar Beet	Barley	Clover hay	Wheat	Potatoes
Cultivations—						
Ploughed	Sept. 9, March 25	Feb. 9		Sept. 7	Sept. 8, March 24	Oct. 2
Harrowed	Sept. 24, April 29	March 23, May 3, 5	April 17	Sept. 24, Oct. 21, 30, April 7, 12, 14, May 3	Oct. 19, 21, 30, April 7, May 3, 5, 22	Oct. 4, 19, 21, April 7, 12, May 3
Rolled	May 3		April 17			
Singled	June 10, 17					
Hoed	June 7, 11, 17, Aug. 3, 12				June 11, 17	
Ridged					April 8, May 11, June 23	

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ROTHAMSTED, 1937

Wheat—BW, Plots 1-15
Yields in lb., grain above, straw below

2N	4K	4P	3P	1P
61.7	64.1	61.8	57.2	65.1
139.8	148.9	156.2	141.8	144.9
3K	1N	2K	4N	0P
51.9	57.6	54.5	54.4	61.6
129.1	130.4	142.5	164.6	142.9
0N	1K	0K	2P	3N
69.4	66.2	58.4	71.0	78.9
123.1	158.8	135.1	146.0	168.1

N ↑

Sugar Beet—BS, Plots 16-30
Yields in lb., roots (dirty) above, tops centre, sugar percentage below

2P	3K	1K	2K	2N
444	519	497	509	463
289	352	338	328	336
17.22	17.83	17.16	16.93	16.91
4K	1P	0K	4P	3P
511	543	515	559	427
430	437	394	448	339
16.85	17.45	16.91	16.94	17.16
0P	4N	3N	1N	0N
569	562	655	525	397
472	531	422	366	307
16.59	17.28	17.16	17.02	17.22

Barley—BB, Plots 31-45
Yields in lb., grain above, straw below

1P	4N	4K	1N	2K
74.5	85.9	72.2	59.4	68.6
102.0	121.1	108.8	86.6	96.9
2P	0P	3K	3P	4P
76.6	77.5	80.3	82.8	74.7
101.9	112.5	111.7	111.2	93.3
3N	2N	0N	1K	0K
68.2	72.3	55.8	69.7	49.2
92.8	102.7	89.2	97.8	69.8

N ↑

Clover Hay—BC, Plots 46-60
Yields in lb.

2K	4N	0N	3P	1P
127	127	128	118	126
0K	3N	1N	2P	0P
102	106	99	116	123
1K	4P	2N	4K	3K
117	134	104	129	127

Potatoes—BP, Plots 61-75
Yields in lb.

3N	4N	0N	4K	0K
262.7	299.4	271.5	316.6	204.7
2P	0P	1N	4P	3P
279.1	305.1	279.6	294.2	286.5
1P	2N	3K	1K	2K
236.0	286.2	333.9	332.3	348.0

N ↑

Rye—BR, Plots 76-90
Yields in lb., grain above, straw below

3N	4N	2N	4P	4K
64.4	73.1	57.6	65.2	54.9
110.6	121.9	106.4	110.3	98.6
1K	2K	3P	1P	2P
57.0	57.4	62.4	59.6	63.3
100.0	99.6	108.1	103.4	105.7
0K	1N	0N	3K	0P
68.1	58.0	42.5	67.4	62.7
115.4	89.5	65.0	114.1	105.8

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WOBURN, 1937

Potatoes—CP, Plots 1-15
Yields in lb.

N.W. ↑

1K	3P	2P	1P	2N
294	303	281	242	272
2K	4P	4N	4K	1N
280	329	365	277	219
0K	3N	0P	0N	3K
249	330	243	218	258

Rye—CR, Plots 16-30
Yields in lb., grain above, straw below

1N	4P	3K	2P	1K
40.0	56.0	61.7	56.7	55.7
64.2	80.2	84.2	86.2	87.2
0N	3P	0P	4N	3N
44.5	59.5	63.5	72.0	70.0
50.2	75.2	81.2	113.2	99.2
2N	1P	4K	2K	0K
55.0	59.5	55.5	59.7	63.7
84.2	91.2	94.2	85.2	96.2

Wheat—CW, Plots 31-45
Yields in lb., grain above, straw below

N.W. ↑

2K	3P	2P	0P	0N
34.2	35.5	40.0	44.0	31.0
60.5	65.5	76.7	82.7	50.7
4P	1K	4N	4K	1N
39.2	38.7	52.0	43.5	31.5
71.5	68.5	97.5	74.7	56.5
0K	1P	3N	3K	2N
38.2	41.7	44.0	42.2	41.2
64.5	73.7	79.7	82.5	72.5

Barley—CB, Plots 46-60
Yields in lb., grain above, straw below

0P	4K	2K	4N	4P
71.0	68.2	77.5	79.7	77.7
76.7	73.7	79.7	97.7	81.7
1P	2P	0K	2N	3P
71.0	71.7	82.7	68.7	75.7
74.7	80.2	94.7	80.7	94.7
3K	1K	3N	0N	1N
49.2	61.2	85.0	39.0	50.2
57.7	62.7	90.7	61.7	80.7

Sugar Beet—CS, Plots 61-75
Yields in lb., roots (dirty) above, tops centre, sugar percentage below

N.W. ↑

0P	4N	1N	3K	2K
431	567	523	573	537
235	321	283	309	304
16.50	17.45	17.45	18.23	18.15
3N	1P	4K	0K	4P
444	464	586	555	513
248	297	337	335	308
17.02	17.54	18.78	18.24	18.58
2P	2N	0N	3P	1K
474	496	478	582	567
262	301	291	390	315
18.55	18.20	18.52	18.49	18.44

Clover Hay—CC, Plots 76-90
Yields in lb., green weights

4P	0N	3K	4K	0K
828	826	741	728	801
1N	3P	2P	4N	3N
691	684	724	693	700
2N	0P	1P	1K	2K
700	762	767	695	743

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ROTHAMSTED, 1937

1.—Mean yields per acre and increments in yield per cwt. of N, P_2O_5 and K_2O.

		Average, 1930-36	1937	Standard error, 1937
Sugar Beet Roots (washed) tons	Yield	7.51	7.83	
	N	1.17	6.13	
	P	−0.24	−1.57	
	K	0.25	−0.09	
Tops tons	Yield	8.56	6.89	
	N	3.26	**6.01**	±2.35
	P	−1.17	−1.74	±2.35
	K	−0.54	0.61	±1.41
Sugar percentage	Mean	17.14	17.11	
	N	−0.38	0.17	
	P	−0.59	0.27	
	K	0.50	0.22	
Total sugar cwt.	Yield	26.4	26.8	
	N	3.5	**21.5**	±6.4
	P	−1.8	−5.0	±6.4
	K	1.8	0.1	±3.9
Barley Grain cwt.	Yield	28.4	25.4	
	N	5.1	**16.5**	±4.6
	P	3.8	0.7	±4.6
	K	−0.7	**8.1**	±2.7
Straw cwt.	Yield	35.6	35.7	
	N	13.3	16.5	
	P	6.7	−7.0	
	K	3.3	13.2	

		Average 1930-36	1937	Standard error, 1937
Clover Hay Dry matter cwt.	Yield	18.7*	24.5	
	N	14.4*	0.1	±3.5
	P	−0.3*	3.5	±3.5
	K	0.9*	**9.7**	±2.1
Wheat Grain cwt.	Yield	23.8	22.2	
	N	4.6†	−2.1	±6.3
	P	0.3	−1.7	±6.3
	K	1.3	−0.4	±3.8
Straw cwt.	Yield	45.5	51.7	
	N	20.5†	28.7	
	P	2.3	5.6	
	K	2.5	−0.2	
Potatoes tons	Yield	6.72	5.16	
	N	1.84	0.47	±1.37
	P	1.11	0.34	±1.37
	K	2.55	1.60	±0.82
Rye Grain cwt.	Yield	22.5‡	21.8	
	N	1.6‡	**16.1**	±3.4
	P	1.3‡	1.9	±3.4
	K	−0.6‡	−2.3	±2.1
Straw cwt.	Yield	45.7‡	37.0	
	N	10.9‡	32.1	
	P	4.8‡	3.3	
	K	−3.8‡	−2.8	

* Crop failed in 1933 and 1935. † 1931-36. ‡ 1934-36. 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, 1937
	Average 1930-36	1937	Average 1930-36	1937	Average 1930-36	1937	
Sugar Beet—Roots (washed)	1.79	11.74	−0.16	−3.01	1.27	−0.28	
Tops	5.84	**13.07**	−1.91	−3.79	−0.92	2.22	±5.11
Sugar percentage	0.01	0.15	−0.38	0.24	0.73	0.32	
Total sugar	1.42	**12.06**	−0.70	−2.80	2.05	0.07	±3.60
Barley—Grain	2.89	**9.75**	2.06	0.39	−0.56	**7.94**	±2.70
Straw	5.63	6.95	3.10	−2.94	2.43	9.25	
Clover Hay—dry matter	9.64*	0.04	−3.11*	2.16	0.47*	**9.91**	±2.14
Wheat—Grain	3.87†	−1.44	0.20	−1.17	1.14	−0.49	±4.26
Straw	7.61†	8.32	0.60	1.62	1.18	−0.12	
Potatoes	4.17	1.36	2.57	0.99	9.60	7.77	±3.97
Rye—Grain	1.21‡	**11.08**	1.04‡	1.29	−0.86‡	−2.62	±2.36
Straw	4.21‡	13.00	1.30‡	1.32	−2.15‡	−1.86	

* Crop failed in 1933 and 1935. † 1931-1936. ‡ 1934-1936. Significant results in heavy type. Negative sign means depression.

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WOBURN, 1937

1.—Mean yields per acre and increments in yield per cwt. of N, P_2O_5 and K_2O.

		Average 1930-36	1937	Standard error, 1937
Sugar Beet Roots (washed) tons	Yield	7.32	8.32	
	N	3.86	1.05	
	P	0.07	3.06	
	K	0.42	0.23	
Tops tons	Yield	6.58	5.40	
	N	2.57	0.29	±1.36
	P	0.67	2.84	±1.36
	K	1.15	−0.01	±0.82
Sugar percentage	Mean	16.92	18.01	
	N	−0.90	−1.71	
	P	0.06	3.41	
	K	0.74	0.35	
Total Sugar cwt.	Yield	24.8	30.0	
	N	11.8	1.0	±6.0
	P	0.4	**16.1**	±6.0
	K	2.5	1.5	±3.6
Barley Grain cwt.	Yield	23.4	24.5	
	N	17.3	**27.8**	±6.7
	P	0.4	4.3	±6.7
	K	2.2	−5.8	±4.0
Straw cwt.	Yield	39.1	28.3	
	N	19.6	19.6	
	P	−0.1	7.1	
	K	4.3	−6.7	

		Average 1930-36	1937	Standard error, 1937
Clover Hay Dry matter cwt.	Yield	23.0*	51.4	
	N	−10.6*	−6.8	±8.1
	P	−5.0*	−4.3	±8.1
	K	6.6*	−3.8	±4.8
Wheat Grain cwt.	Yield	12.2†	14.2	
	N	14.2†	**13.0**	±2.1
	P	−1.0†	−3.7	±2.1
	K	−0.5†	2.0	±1.2
Straw cwt.	Yield	26.0†	25.7	
	N	31.8†	27.8	
	P	−1.7†	−7.3	
	K	−2.4†	5.0	
Potatoes tons	Yield	8.58	4.95	
	N	4.41	**4.83**	±0.63
	P	0.36	**2.77**	±0.63
	K	0.82	0.14	±0.38
Rye Grain cwt.	Yield	20.2‡	20.8	
	N	11.5‡	**20.2**	±3.3
	P	−1.9‡	−3.6	±3.3
	K	−1.6‡	−1.6	±2.0
Straw cwt.	Yield	36.8‡	30.3	
	N	27.2‡	38.3	
	P	−3.1‡	−4.3	
	K	−2.7‡	−1.0	

*Crop failed in 1934. †1931-1936. ‡1934-1936. 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 Average 1930-36	N 1937	P Average 1930-36	P 1937	K Average 1930-36	K 1937	Standard error, 1937
Sugar Beet—							
Roots (washed)	6.99	1.90	−0.01	5.52	2.16	0.70	
Tops	5.61	0.81	1.53	7.89	3.90	−0.04	±3.79
Sugar percentage	−0.54	−1.43	0.06	2.84	1.09	0.48	
Total sugar	6.25	0.50	0.05	**8.06**	3.10	1.27	±3.02
Barley—Grain	11.76	**17.02**	0.17	2.61	2.84	−5.92	±4.11
Straw	8.17	10.40	0.13	3.78	2.60	−5.94	
Clover Hay—Dry matter	−8.39*	−1.98	−1.46*	−1.24	8.45*	−1.87	±2.36
Wheat—Grain	16.15†	**13.73**	−1.63†	−3.94	0.82†	3.59	±2.17
Straw	18.74†	16.25	−1.39†	−4.25	0.34†	4.83	
Potatoes	8.23	**14.62**	0.08	**8.38**	2.20	0.73	±1.90
Rye—Grain	9.09‡	**14.59**	−1.18‡	−2.60	−2.03‡	−1.88	±2.39
Straw	10.95‡	18.99	−1.29‡	−2.15	−1.95‡	−0.86	

* Crop failed in 1934. † 1931-1936. ‡ 1934-1936. Significant results in heavy type. Negative sign means depression.

THREE COURSE ROTATION EXPERIMENT, ROTHAMSTED, 1937

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 31	May 3	April 30
Manures applied—			
Artificials	Oct. 5, March 31	Sept. 23, May 3	Oct. 26, April 27
Adco and straw	Oct. 5	Sept. 23, 24	Oct. 26–28
Harvested	Sept. 2	Nov. 19–20	Oct. 7
Previous crop	Potatoes	Barley	Sugar Beet
Cultivations—			
Ploughed	Oct. 5, 6, March 19–22	Sept. 23, 24, March 25	Oct. 27, 28, March 23, 24
Harrowed	Oct. 14–17, March 30,31	Oct. 14-17, April 13, 14, 24, 30, May 1, 3	Oct. 29, 30, April 2, 13, 14, 24, 26, May 10
Rolled	Oct. 16, 17, March 30, May 31	Oct. 16, April 30, May 1, 3, 4	April 26, May 10
Singled		June 14	
Hoed		June 2, July 11, Aug. 7, 19	Aug. 19
Ridged			April 26, 27, May 28, June 18, July 27
Grubbed			June 9, July 26

GREEN MANURE CROPS—GREEN WEIGHTS—TONS PER ACRE

Preceding		Manured 1936-37					Manured 1935-36				
		Art'ls.	Adco	St. 1	St. 2	*Mean*	Art'ls.	Adco	St. 1	St. 2	*Mean*
Barley	Vetches	0.79	0.83	0.93	1.02	*0.89*	1.00	0.98	0.77	0.71	*0.86*
	Rye ..	1.87	2.56	1.92	2.10	*2.11*	2.56	2.00	2.21	2.86	*2.41*
Sugar Beet	Vetches	1.66	1.05	1.48	1.35	*1.38*	1.26	1.25	1.20	1.41	*1.28*
	Rye ..	3.22	3.29	2.73	3.46	*3.18*	3.43	2.10	3.65	3.57	*3.19*
Potatoes	Vetches	0.70	1.28	1.29	0.97	*1.06*	0.72	1.28	0.84	1.00	*0.96*
	Rye ..	0.43	0.74	0.91	1.51	*0.90*	1.35	0.95	0.46	1.08	*0.96*

PERCENTAGE DRY MATTER

Preceding		Sample 1	Sample 2
Barley	Vetches	9.60	7.70
	Rye	7.55	10.15
Sugar-Beet	Vetches	5.98	5.88
	Rye	6.48	5.91
Potatoes	Vetches	8.65	6.67
	Rye	6.47	5.86

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

Potatoes—DP, Plots 49-72. Yields in lb.

N

St *1* R I 304	Ad R I 216	Ad V II 169	Ad V I 155	Ad R II 141	St *1* V I 202
St *1* O I 257	St *2* V II 189	St *1* V II 162	St *2* V I 193	St *2* R I 188	St *2* O I 194
Ar R I 195	Ar R II 143	Ar O I 191	Ad O I 149	St *1* O II 180	Ar V II 180
St *1* R II 186	Ad O II 163	St *2* R II 173	St *2* O II 184	Ar V I 302	Ar O II 190

Barley—DB, Plots 25-48. Yields in lb. grain above, straw below

N

St *1* O II 37.2 41.3	Ad O I 35.1 42.9	Ad R II 23.8 32.7	Ar V II 34.3 40.7	Ar R I 50.2 61.8	St *2* O I 43.1 45.8
St *2* O II 39.0 44.0	Ad V II 42.0 52.5	St *2* R I 37.6 45.9	St *2* V I 59.1 43.9	St *1* R II 29.3 39.7	Ar O I 56.9 62.1
Ar R II 29.1 38.9	Ad O II 43.6 52.9	St *2* R II 29.2 39.3	St *1* V I 56.3 60.7	St *1* R I 42.7 48.3	Ad V I 38.2 43.3
Ad R I 19.2 29.8	Ar V I 45.5 60.6	St *1* O I 46.2 44.8	Ar O II 34.0 37.0	St *2* V II 42.6 48.4	St *1* V II 34.7 42.8

Sugar Beet—DS, Plots 1-24. Yields in lb. roots (dirty) above, tops centre, sugar percentage below

N

St *1* R II 282 208 16.79	St *2* R I 322 251 17.40	Ar R I 374 272 17.19	St *2* O II 375 288 17.16	Ar O II 369 300 16.76	Ad O I 274 318 16.56
St *1* O I 419 370 17.54	St *2* R II 392 305 17.89	St *1* O II 374 319 17.54	Ar V II 428 320 17.74	Ad O II 390 321 17.48	St *2* O I 246 255 16.53
Ar R II 354 280 17.54	St *2* V II 469 368 17.54	Ar V I 504 458 17.05	St *1* R I 435 355 17.63	Ad R I 324 230 17.45	St *1* V II 292 211 17.40
Ad V II 464 404 17.25	Ar O I 531 490 17.77	Ad V I 386 342 16.82	St *2* V I 363 332 17.48	St *1* V I 338 305 17.05	Ad R II 244 182 17.63

SUMMARY OF RESULTS

		Manured 1936-7					Manured 1935-6				
		Artificials	Adco	Straw St 1	Straw St 2	*Mean*	Artificials	Adco	Straw St 1	Straw St 2	*Mean*
Barley Grain cwt. p.a.	None	25.4	15.7	20.6	19.2	*20.2*	15.2	19.5	16.6	17.4	*17.2*
	Vetches	20.3	17.1	25.1	26.4	*22.2*	15.3	18.7	15.5	19.0	*17.1*
	Rye	22.4	8.6	19.1	16.8	*16.7*	13.0	10.6	13.1	13.0	*12.4*
	Mean	*22.7*	*13.8*	*21.6*	*20.8*	*19.7*	*14.5*	*16.3*	*15.1*	*16.5*	*15.6*
Straw cwt. p.a.	None	27.7	19.2	20.0	20.4	*21.8*	16.5	23.6	18.4	19.6	*19.5*
	Vetches	27.1	19.3	27.1	19.6	*23.3*	18.2	23.4	19.1	21.6	*20.6*
	Rye	27.6	13.3	21.6	20.5	*20.8*	17.4	14.6	17.7	17.5	*16.8*
	Mean	*27.5*	*17.3*	*22.9*	*20.2*	*22.0*	*17.4*	*20.5*	*18.4*	*19.6*	*19.0*
Sugar Beet Roots washed tons p.a.	None	9.31	4.87	7.62	4.45	*6.56*	5.93	7.46	7.03	6.43	*6.71*
	Vetches	9.44	7.21	6.14	6.67	*7.36*	7.96	8.61	5.55	8.80	*7.73*
	Rye	6.99	6.08	8.57	5.75	*6.85*	6.44	4.60	4.85	6.97	*5.72*
	Mean	*8.58*	*6.05*	*7.44*	*5.62*	*6.92*	*6.78*	*6.89*	*5.81*	*7.40*	*6.72*
Tops tons p.a.	None	10.94	7.10	8.26	5.69	*8.00*	6.69	7.17	7.12	6.44	*6.86*
	Vetches	10.21	7.62	6.81	7.42	*8.02*	7.15	9.01	4.71	8.20	*7.27*
	Rye	6.08	5.13	7.92	5.60	*6.18*	6.25	4.07	4.63	6.81	*5.44*
	Mean	*9.08*	*6.62*	*7.66*	*6.24*	*7.40*	*6.70*	*6.75*	*5.49*	*7.15*	*6.52*
Sugar percentage	None	17.77	16.56	17.54	16.53	*17.10*	16.76	17.48	17.54	17.16	*17.24*
	Vetches	17.05	16.82	17.05	17.48	*17.10*	17.74	17.25	17.40	17.54	*17.48*
	Rye	17.19	17.45	17.63	17.40	*17.42*	17.54	17.63	16.79	17.89	*17.46*
	Mean	*17.34*	*16.94*	*17.41*	*17.14*	*17.21*	*17.35*	*17.45*	*17.24*	*17.53*	*17.39*
Total sugar cwt. p.a.	None	33.1	16.2	26.7	14.7	*22.7*	19.9	26.1	24.6	22.1	*23.2*
	Vetches	32.2	24.2	20.9	23.3	*25.2*	28.2	29.7	19.3	30.9	*27.0*
	Rye	24.0	21.3	30.2	20.0	*23.9*	22.6	16.2	16.3	25.0	*20.0*
	Mean	*29.8*	*20.6*	*25.9*	*19.3*	*23.9*	*23.6*	*24.0*	*20.1*	*26.0*	*23.4*
Potatoes tons p.a.	None	4.26	3.32	5.73	4.33	*4.41*	4.24	3.64	4.02	4.12	*4.01*
	Vetches	6.73	3.46	4.51	4.30	*4.75*	4.01	3.77	3.62	4.21	*3.90*
	Rye	4.35	4.82	6.78	4.18	*5.03*	3.19	3.14	4.15	3.85	*3.58*
	Mean	*5.11*	*3.87*	*5.67*	*4.27*	*4.73*	*3.81*	*3.52*	*3.93*	*4.06*	*3.83*

K

LONG PERIOD CULTIVATION EXPERIMENT, 1937

Long Hoos V

(For details see 1934 Report, p. 175)

CULTIVATIONS, Etc.

	Wheat	Mangolds	Barley
Variety	Victor	Yellow Globe	Plumage Archer
Date of sowing	Nov. 23	May 3	April 13
Manures applied—			
Cyanamide	April 5	April 28	March 30
Nitro-chalk	April 5	May 3, June 23	April 6
Super. & mur. pot.		May 3	
Harvested	Aug. 19	Oct. 26-28	Aug. 30
Previous crop	Barley	Wheat	Mangolds
Cultivations—			
Ploughed	Nov. 11	Sept. 13*, March 26	Nov. 16, March 25
Simared	Nov. 20	March 26	March 25
Cultivated	Nov. 20	March 26	Nov. 16, March 25
Harrowed	Nov. 23, May 3	Oct. 14, April 1, 23, 26, May 1, 3	April 1, 12, 13
Hoed		June 1, July 24	
Rolled	May 4	May 1, 3, 4	May 31
Singled		June 17-19	

*All plots ploughed shallow.

PLAN AND YIELDS IN LB.

Mangolds

Roots Left, Tops Right

1	S D N	231.5	90.5	S D Cy	326.5	68.0	73
	S Sh N	293.0	83.5	P D Cy	365.5	77.5	
	C D Cy	295.5	75.5	P Sh N	316.0	71.0	
	P Sh Cy	296.0	77.5	C D N	269.0	68.0	
	C Sh N	352.5	88.0	P Sh Cy	291.0	65.0	
B	P D Cy	362.5	90.0	C D Cy	356.0	76.0	A
	C D N	328.5	90.5	C Sh Cy	271.0	61.0	
	P Sh N	387.5	100.0	P D N	401.5	86.0	
	P D N	441.5	108.0	S D N	377.0	77.0	
	C Sh Cy	347.0	84.5	S Sh Cy	323.5	67.5	
N ↑	S Sh Cy	323.5	75.5	S Sh N	325.5	68.5	
	S D Cy	319.0	77.5	C Sh N	297.5	66.5	
	C Sh N	340.0	81.5	C D Cy	244.5	66.0	
	S Sh Cy	346.0	73.0	P Sh Cy	374.5	81.5	
	P D Cy	360.5	81.5	S D Cy	342.5	82.5	
	C D Cy	259.5	64.0	P D Cy	391.0	83.5	
	C Sh Cy	383.0	88.0	S Sh N	431.5	100.0	
C	P Sh Cy	387.0	85.0	C Sh Cy	336.0	83.5	C
	S Sh N	371.5	84.5	S D N	373.5	80.0	
	C D N	287.0	71.0	C D N	293.5	73.5	
	S D N	368.5	77.5	P Sh N	354.0	78.5	
	P Sh N	350.5	77.5	P D N	361.0	81.5	
	S D Cy	325.0	70.0	S Sh Cy	353.0	67.5	
	P D N	259.5	67.5	C Sh N	282.0	64.5	

Wheat
Grain Left, Straw Right

	S Sh N	22.2	38.8	S Sh N	16.1	43.4	
	C Sh N	18.3	34.2	S D Cy	27.8	44.2	
	C Sh Cy	22.7	39.3	P Sh Cy	35.2	48.8	
	P D N	40.4	57.6	P Sh N	36.5	56.5	
	C D N	23.0	39.5	P D Cy	31.3	48.2	
	P Sh Cy	36.4	49.1	C D Cy	11.7	27.8	
C	C D Cy	21.6	37.9	S D N	14.9	36.1	C
	S D Cy	25.8	41.7	P D N	31.2	52.3	
	P Sh N	36.2	55.8	S Sh Cy	13.8	29.2	
	S Sh Cy	20.7	34.8	C Sh N	9.8	29.2	
	S D N	25.1	41.4	C D N	14.2	31.3	
	P D Cy	39.0	59.0	C Sh Cy	10.0	28.5	
	P Sh N	39.9	58.6	C Sh Cy	17.7	29.8	
	C D Cy	23.8	33.7	C D Cy	17.0	33.0	
	C D N	17.4	35.6	S Sh N	12.6	32.9	
	C Sh N	14.8	34.2	P Sh Cy	24.6	43.9	
	S D N	23.6	41.4	S Sh Cy	13.3	26.7	
A	P D N	37.1	54.4	S D N	19.5	37.0	B
	S D Cy	32.7	48.3	C D N	24.0	42.0	
	S Sh N	34.7	48.3	P D Cy	33.6	45.9	
	C Sh Cy	25.0	37.0	P Sh N	30.0	48.5	
	S Sh Cy	33.7	43.8	P D N	31.9	52.6	
	P D Cy	37.2	53.8	C Sh N	23.1	38.9	
	P Sh Cy	34.4	48.1	S D Cy	22.2	38.8	

Barley
Grain Left, Straw Right

	C Sh N	26.8	42.2	S Sh N	27.5	39.5	
	S Sh N	25.9	40.6	S D N	31.5	49.5	
	P Sh Cy	29.4	46.1	S Sh Cy	29.5	45.5	
	C D Cy	24.2	39.3	C D Cy	27.5	40.5	
	C Sh Cy	26.1	42.9	S D Cy	29.4	41.1	
C	C D N	22.2	40.3	P Sh N	30.6	44.4	A
	S Sh Cy	22.1	39.4	P D Cy	29.6	42.4	
	S D Cy	24.6	40.4	C Sh N	24.4	37.6	
	P D Cy	25.9	42.1	P D N	27.4	41.6	
	P Sh N	29.7	43.8	C D N	24.2	35.8	
	P D N	23.8	39.2	C Sh Cy	22.3	35.7	
	S D N	24.1	35.4	P Sh Cy	23.9	36.1	
	C Sh N	24.8	38.2	S D Cy	30.1	42.9	
	P D N	31.1	43.9	C D Cy	25.6	37.4	
	P Sh N	28.1	42.9	C Sh Cy	27.9	42.1	
	S Sh N	24.4	35.1	P Sh N	30.2	45.8	
	P Sh Cy	26.4	42.6	C D N	25.4	35.6	
B	C Sh Cy	21.2	30.8	S Sh N	24.2	37.3	C
	P D Cy	24.2	40.3	S D N	23.0	36.0	
	S D N	22.5	35.5	S Sh Cy	22.3	35.2	
	C D Cy	20.2	32.3	P D Cy	25.6	43.4	
	S D Cy	24.0	37.5	P D N	26.4	40.6	
	C D N	24.1	35.4	C Sh N	25.9	37.1	
72	S Sh Cy	18.7	28.8	P Sh Cy	28.4	42.1	144

Summary of Results

Last Year / This Year	Continuous P / P	S / S	C / C	*Mean*	Cycle A C / P	P / S	S / C	Cycle B S / P	C / S	P / C	*Mean*
Wheat				GRAIN : cwt. per acre							
N D ..	20.8	11.6	10.8	*14.4*	21.5	13.7	10.1	18.5	11.3	13.9	*14.8*
Sh ..	21.1	11.1	8.2	*13.5*	23.2	20.1	8.6	17.4	7.3	13.4	*15.0*
Cy D ..	20.4	15.6	9.7	*15.2*	21.6	19.0	13.8	19.5	12.9	9.9	*16.1*
Sh ..	20.8	10.0	9.5	*13.4*	20.0	19.6	14.5	14.3	7.7	10.3	*14.4*
St. Errors		±1.32		*±0.762*							
				STRAW : cwt. per acre							
N D ..	31.9	22.5	20.5	*25.0*	31.6	24.0	20.7	30.5	21.5	24.4	*25.4*
Sh ..	32.6	23.9	18.4	*25.0*	34.0	28.0	19.8	28.1	19.1	22.6	*25.3*
Cy D ..	31.1	24.9	19.1	*25.0*	31.2	28.0	19.6	26.6	22.5	19.2	*24.5*
Sh ..	28.4	18.6	19.7	*22.2*	27.9	25.4	21.5	25.5	15.5	17.3	*22.2*
Mangolds				ROOTS : tons per acre							
N D ..	18.01	21.53	16.84	*18.79*	23.30	21.88	15.61	25.62	13.44	19.06	*19.82*
Sh ..	20.44	23.30	18.05	*20.60*	18.34	18.89	17.27	22.49	17.00	20.46	*19.08*
Cy D ..	21.81	19.37	14.62	*18.60*	21.21	18.95	20.66	21.04	18.51	17.15	*19.59*
Sh ..	22.10	20.28	20.86	*21.08*	16.89	18.77	15.73	17.18	18.77	20.14	*17.91*
St. Errors		±1.25		*±0.722*							
				TOPS : tons per acre							
N D ..	4.32	4.57	4.19	*4.36*	4.99	4.47	3.95	6.27	5.25	5.25	*5.03*
Sh ..	4.53	5.35	4.24	*4.71*	4.12	3.98	3.86	5.80	4.85	5.11	*4.62*
Cy D ..	4.79	4.43	3.77	*4.33*	4.50	3.95	4.41	5.22	4.50	4.38	*4.49*
Sh ..	4.83	4.08	4.98	*4.63*	3.77	3.92	3.54	4.50	4.38	4.90	*4.17*
Barley				GRAIN : cwt. per acre							
N D ..	14.6	13.7	13.8	*14.0*	15.9	18.3	14.0	18.0	13.1	14.0	*15.6*
Sh ..	17.4	14.5	15.3	*15.7*	17.8	16.0	14.2	16.3	14.2	14.4	*15.5*
Cy D ..	14.9	15.9	14.4	*15.1*	17.2	17.1	16.0	14.0	13.9	11.7	*15.0*
Sh ..	16.8	12.9	15.7	*15.1*	13.9	17.1	12.9	15.3	10.9	12.3	*13.7*
St. Errors		±0.620		*±0.358*							
				STRAW : cwt. per acre							
N D ..	23.2	20.7	22.0	*22.0*	24.1	28.7	20.8	25.5	20.6	20.5	*23.4*
Sh ..	26.0	22.6	23.0	*23.9*	25.8	22.9	21.8	24.9	20.4	22.2	*23.0*
Cy D ..	24.8	24.2	22.3	*23.8*	24.6	23.9	23.5	23.4	21.8	18.7	*22.6*
Sh ..	25.6	21.6	24.7	*24.0*	21.0	26.4	20.7	24.7	16.7	17.9	*21.2*

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Mean of Nitro-Chalk and Cyanamide

Last year / This year	Continuous P / P	S / S	C / C	*Mean*	Cycle A C / P	P / S	S / C	Cycle B S / P	C / S	P / C	*Mean*
Wheat				GRAIN : cwt. per acre							
D	20.6[1]	13.6[1]	10.2[1]	*14.8*[3]	21.6	16.4	12.0	19.0	12.1	11.9	*15.5*
Sh	21.0[1]	10.6[1]	8.8[1]	*13.5*[3]	21.6	19.8	11.6	15.8	7.5	11.8	*14.7*
Mean ..	*20.8*[2]	*12.1*[2]	*9.5*[2]	*14.1*	*21.6*	*18.1*	*11.8*	*17.4*	*9.8*	*11.8*	*15.1*
St. Errors (1) ±0.934, (2) ±0.661, (3) ±0.539.											
				STRAW : cwt. per acre							
D	31.5	23.7	19.8	*25.0*	31.4	26.0	20.2	28.6	22.0	21.8	*25.0*
Sh	30.5	21.2	19.0	*23.6*	31.0	26.7	20.6	26.8	17.3	20.0	*23.7*
Mean ..	*31.0*	*22.4*	*19.4*	*24.3*	*31.2*	*26.4*	*20.4*	*27.7*	*19.6*	*20.9*	*24.4*
Mangolds				ROOTS : tons per acre							
D	19.91[1]	20.45[1]	15.73[1]	*18.70*[3]	22.26	20.42	18.14	23.33	15.98	18.10	*19.70*
Sh	21.27[1]	21.79[1]	19.46[1]	*20.84*[3]	17.62	18.83	16.50	19.84	17.88	20.30	*18.50*
Mean ..	*20.59*[2]	*21.12*[2]	*17.60*[2]	*19.77*	*19.94*	*19.62*	*17.32*	*21.58*	*16.93*	*19.20*	*19.10*
St. Errors (1) ±0.884, (2) ±0.625, (3) ±0.510.											
				TOPS : tons per acre							
D	4.56	4.50	3.98	*4.35*	4.74	4.21	4.18	5.74	4.88	4.82	*4.76*
Sh	4.68	4.72	4.61	*4.67*	3.94	3.95	3.70	5.15	4.62	5.00	*4.39*
Mean ..	*4.62*	*4.61*	*4.30*	*4.51*	*4.34*	*4.08*	*3.94*	*5.44*	*4.75*	*4.91*	*4.58*
Barley				GRAIN : cwt. per acre							
D	14.8[1]	14.8[1]	14.1[1]	*14.6*[3]	16.6	17.7	15.0	16.0	13.5	12.8	*15.3*
Sh	17.1[1]	13.7[1]	15.5[1]	*15.4*[3]	15.8	16.6	13.6	15.8	12.6	13.4	*14.6*
Mean ..	*16.0*[2]	*14.2*[2]	*14.8*[2]	*15.0*	*16.2*	*17.2*	*14.3*	*15.9*	*13.0*	*13.1*	*15.0*
St. Errors (1) ±0.438, (2) ±0.310, (3) ±0.253.											
				STRAW : cwt. per acre							
D	24.0	22.4	22.2	*22.9*	24.4	26.3	22.2	24.4	21.2	19.6	*23.0*
Sh	25.8	22.1	23.8	*23.9*	23.4	24.6	21.2	24.8	18.6	20.0	*22.1*
Mean ..	*24.9*	*22.2*	*23.0*	*23.4*	*23.9*	*25.4*	*21.7*	*24.6*	*19.9*	*19.8*	*22.6*

Conclusions

For wheat grain the differences between the effects of the continuous cultivations were very striking, the plots ploughed every year giving a mean yield of 20.8 cwt. per acre, the simared plots giving 12.1 cwt. and the cultivated plots 9.5 cwt. The results were similar with the rotating cultivations, except that in cycle B the cultivated plots (ploughed last year) gave a higher yield than the simared plots.

For barley grain the plots ploughed every year gave a significantly higher yield than the simared or cultivated plots, there being little difference between the last two. The results were similar in cycle B of the rotating cultivations, but in cycle A the plots simared this year and ploughed last year gave the highest yields.

For mangolds roots there was little difference between the plots ploughed every year and those simared every year, but the cultivated plots gave significantly lower yields. Cycle A showed the same effects, but in cycle B the plots cultivated this year and ploughed last year gave higher yields than the plots simared this year and cultivated last year.

It will be noted from the above conclusions that in all three crops there is some indication of a beneficial residual effect of the ploughing last year compared with simaring and cultivating last year.

For mangolds roots the shallow cultivations gave a significantly higher yield than the deep cultivations on the continuous part of the experiment. This result did not however, appear with the rotating cultivations. For wheat and barley grain the differences between deep and shallow cultivations were not consistent.

There were no significant differences between nitro-chalk and cyanamide.

It should be noted that the ploughing, simaring and cultivating were again carried out at the same time, except on the wheat crop, when only a few days separated them.

NEW GREEN MANURING EXPERIMENT

STACKYARD, WOBURN

(For details see 1936 Report, p. 203)

Cultivations, etc.,

UPPER HALF: Ploughed: March 3-16. Lime applied, harrowed and barley drilled: March 23. Harrowed, clover and ryegrass drilled: May 5. Horse hoed: June 11. Harvested: Aug. 19. Variety: Plumage Archer. Previous crop: Kale.

LOWER HALF: Ploughed (except clover and ryegrass plots): Sept. 17 and 18. Harrowed, mustard and tares drilled: Sept. 24. Mustard, tares and weeds on fallow plots ploughed in: April 13 and 14. Harrowed, mustard and tares redrilled: April 22. Clover and ryegrass cut: June 16. Dung applied: June 30-July 1. Straw applied and ploughed: July 3-9. Harrowed, rolled and kale drilled: July 10. Sulphate of ammonia applied to all plots: July 12. Harrowed, kale resown and rolled: Aug. 16. Horse hoed all plots: Sept. 9. Harvested: Jan. 11 and 14. Variety: Thousand head. Previous crop: Wheat.

SPECIAL NOTES: On the lower half of the experiment, clover and ryegrass were sown in the preceding wheat crop. A basal dressing of 4 cwt. per acre of mineral manures (3 parts superphosphate and 1 part muriate of potash) should have been applied on this half, but was unfortunately omitted.

WI—STACKYARD, 1937

Upper half—Barley. Plan and yields of grain in lb.

20	M(C)	—	—	N	1336	T	D	S	2N	1417	40
	M	—	—	N	1145	T(R)	—	—	N	920	
	F	—	S	2N	1145	F	—	—	2N	975	
	M	—	S	2N	1431	M	D	S	N	1410	
	T	D	S	N	1622	F	D	—	2N	1547	
	T	—	—	N	1438	M(C)	D	—	2N	1410	
	M(C)	D	S	2N	1560	T	—	S	N	1097	
	T(R)	D	—	2N	1642	F	D	S	N	1363	
	M(C)	—	S	N	1302	M(C)	—	S	2N	1002	
	T(R)	—	S	2N	1193	F	—	—	N	961	
	F	D	—	N	1383	T(R)	D	S	N	1281	
	M	—	—	2N	1261	F	D	S	2N	1547	
	M(C)	D	—	N	1451	T	D	—	N	1458	
	F	—	S	N	1090	T(R)	—	S	N	1036	
	M(C)	—	—	2N	1451	M	—	S	N	852	
	T(R)	D	S	2N	1635	M	D	—	N	1233	
	T	—	S	2N	1417	M	D	S	2N	1505	
	M(C)	D	S	N	1546	T	—	—	2N	1506	
	T(R)	—	—	2N	1001	T(R)	D	—	N	1370	
1	M	D	—	2N	1859	T	D	—	2N	2017	21

Lower half—Kale. Plan and yields in lb.

20	C	D	S	N	—*	R	—	S	2N	—*	40
	M	D	—	2N	—*	M	—	S	N	—*	
	F	D	—	2N	193.4*	F	—	—	N	124.0*	
	T	—	S	N	100.0*	R	D	—	N	148.4*	
	T	D	—	2N	307.7	T	D	S	2N	161.1*	
	F	D	S	N	316.1	F	—	S	2N	214.1	
	F	D	S	2N	419.0	R	D	S	N	183.7	
	T	—	S	2N	307.7	F	—	—	2N	251.1	
	R	—	S	N	205.3	C	D	—	2N	269.8	
	T	D	—	N	373.0	R	—	—	2N	226.7	
	M	—	—	N	234.0	T	—	—	2N	357.5	
	F	—	S	N	264.0	M	—	S	2N	309.0	
	C	—	S	2N	259.9	F	D	—	N	346.1	
	R	—	—	N	282.8	C	D	S	2N	346.6	
	R	D	S	2N	393.6	M	D	S	N	310.5	
	T	—	—	N	311.7	C	—	S	N	293.9	
	M	D	—	N	380.5	R	D	—	2N	412.4	
	M	—	—	2N	295.4	C	—	—	2N	355.4	
	T	D	S	N	440.7	M	D	S	2N	324.6	
1	C	D	—	N	329.7	C	—	—	N	214.3	21

* Badly attacked by pigeons; not used in analysis.

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Leys and Green Manures : dry matter and nitrogen per cent.

	Fallow	Tares	Mustard	Clover	Ryegrass
	Winter crop : buried.			Dry matter : carted off.	
Dry matter, cwt. ..	1.3	4.4	4.0	40.8	18.8
Nitrogen per cent. ..	2.78	3.69	3.01	2.94	0.97
	Spring crop : buried.			Stubble : buried.	
Dry matter : cwt. ..	8.8	15.8	16.1	21.6	24.1
Nitrogen : per cent. ..	2.05	2.31	1.58	1.84	0.53

Notes : The dry matter yields for the individual plots are also available. The fallow figures are the weights and nitrogen per cents. of the weeds on the plots.

Summary of Results

Upper half : barley grain, cwt. per acre

Residual effects of green manures and fertilisers applied to Kale in 1936.

Green manure	None	Tares		Mustard		*Mean*	*Increase*
Ley sown under barley	None	None	Ryegrass	None	Clover	($\pm$*0.306*)	($\pm$*0.433*)
No dung	9.3	12.2	9.2	10.5	11.4	*10.5*	
Dung	13.0	14.6	13.2	13.4	13.3	*13.5*	*+3.0*
No straw	10.8	14.3	11.0	12.3	12.6	*12.2*	
Straw	11.5	12.4	11.5	11.6	12.0	*11.8*	*—0.4*
2 cwt. sulph. amm. ..	10.7	12.5	10.2	10.4	12.6	*11.3*	
4 cwt. sulph. amm. ..	11.6	14.2	12.2	13.5	12.1	*12.7*	*+1.4*
Mean ($\pm$*0.484*) ..	*11.2*	*13.4*	*11.2*	*12.0*	*12.4*	*12.0*	

Interactions of fertilisers

Grain cwt. per acre ($\pm$0.613)

	2 cwt. sulph. amm.		4 cwt. sulph. amm.	
	No dung	Dung	No dung	Dung
No straw ..	10.3	12.3	11.1	15.1
Straw ..	9.6	12.9	11.1	13.7

Conclusions

Upper half :—The green manures grown before the preceding kale crop increased the yield of barley grain, the increase to tares being 2.2 cwt. per acre and to mustard 0.8 cwt. per acre. The difference between these increases was not significant. Clover sown under the barley appears to have had little effect on the yield of barley grain, but there are indications that the undersowing of ryegrass reduced the yield of barley grain.

There were also significant residual effects of the manurial treatments applied to kale. Dung increased the barley grain by 3.0 cwt. per acre and sulphate of ammonia by 1.4 cwt. per acre. Straw had little effect.

Lower half :—The crop of kale was a very poor one. Nine plots had to be rejected on account of partial or complete failure. The mean yield on the remaining plots was 3.74 tons per acre. There were no significant differences between the effects of the green manures or leys. Dung produced a significant increase of 0.88 tons per acre, but sulphate of ammonia and straw had little effect.

https://doi.org/10.23637/ERADOC-1-69

SPRING OATS

Residual effect of dung, straw and sulphate of ammonia applied to the preceding potato crop

RO—Great Harpenden, 1937

Plan and yields in lb., grain above, straw below

1	St N 43.6 61.4	DL 44.8 67.7	St 48.1 64.9	DL St 56.1 76.4	DE 70.1 90.9	DE St 64.8 87.2	DE N 64.1 81.9	DL St 72.9 89.1	8
	N 50.6 71.4	DE St N 64.0 86.0	DL St N 71.4 91.1	DE 66.9 83.1	Nil 66.1 80.9	DL 51.8 82.2	St 55.8 76.2	DE St N 80.5 98.5	
W ↑	Nil 45.2 60.8	DLN 63.3 82.7	DE St 71.9 90.1	DEN 63.0 77.0	DLN 69.8 85.7	St N 43.8 73.2	DL St N 58.4 82.6	N 64.0 80.0	
	Nil 43.2 59.3	DE St N 58.0 82.5	St 55.9 76.1	N 55.1 70.9	DE 68.1 84.4	St N 54.3 79.2	St 47.3 67.7	DEN 68.6 93.9	
	St N 42.3 62.2	DE N 50.2 72.3	DL St N 59.2 74.3	DLSt 58.1 72.4	DL St N 69.4 84.6	DL 28.7 62.3	DL St 42.4 72.1	DLN 62.3 85.7	
41	DE St 44.2 67.3	DE 53.7 70.3	DL 53.7 72.5	DLN 52.4 67.1	DE St 59.1 79.9	DE St N 32.5 64.0	N 44.4 68.1	Nil 63.9 83.6	48

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

AREA OF EACH PLOT : 1/40 acre (45.5 lks. × 54.9 lks.)

TREATMENTS (applied to potatoes in 1936) : 3 × 2 × 2 factorial design.

Dung : None, 15 tons per acre ploughed in in December (DE), or stored and applied in the bouts (DL).

Straw : None, 40 cwt. per acre (chaffed) (ST), ploughed in in December, except when applied with DL, for which straw and dung were mixed and stored.

Sulphate of ammonia : None, 0.4 cwt.N per acre applied in the bouts (N).

BASAL MANURING (applied in 1936) : 0.5 cwt. P_2O_5 per acre as superphosphate, and 1 cwt. K_2O per acre as sulphate of potash applied in the bouts.

CULTIVATIONS, ETC. : Ploughed on various dates during Jan. Drilled : April 12. Sulphate of ammonia applied : April 13. Rolled : May 5. Clover sown and harrowed in : May 19. Rolled : May 29. Harvested : Aug. 17. Variety : Marvellous. Previous crop : Potatoes (See 1936 Report, p. 213).

STANDARD ERROR PER PLOT : Grain 3.39 cwt. per acre or 16.8%.

Summary of Results : Yields of separate treatments

		No dung	Dung ploughed in	Dung in the bouts
GRAIN : cwt. per acre (±0.848)				
No sulph. amm. ..	No straw	19.5	23.1	16.0
	Straw	18.5	21.4	20.5
Sulph. amm.	No straw	19.1	22.0	22.1
	Straw	16.4	21.0	23.1
STRAW : cwt. per acre				
No sulph. amm. ..	No straw	25.4	29.3	25.4
	Straw	25.4	29.0	27.7
Sulph. amm.	No straw	25.9	29.0	28.7
	Straw	24.6	29.6	29.7

Conclusions

The crop was a variable one and the standard error is rather large. On most plots dung, applied to the potatoes in 1936, increased the yield of oats grain by about 3.6 cwt. per acre. There was however an anomalous depression of 3.5 cwt. per acre due to dung on the plots receiving dung in the bouts but no sulphate of ammonia nor straw in 1936. This depression is statistically significant, but no explanation can be found for it.

The residual effect of sulphate of ammonia was small. Omitting the plots which were anomalously depressed, there is some indication of a small residual depression in oats grain due to straw.

POTATOES

Effect of Dung, ploughed in in January, or applied in the bouts, and of Straw, Sulphate of Ammonia, Superphosphate and Sulphate of Potash

RP—Gt. Knott, 1937

Total produce in lb. above, percentage ware below

1	DeN$_1$P 289 90.0	DeSt 158 88.6	N$_2$St 192 88.0	N$_2$StP 281 91.1	Nil 147 84.0	DeN$_2$StK 348 94.0	6
	P 168 85.7	StK 149 86.9	DeN$_2$ 322 91.9	StPK 159 86.8	DlN$_1$StP 387 93.7	DlN$_2$ 406 95.7	
	N$_1$ 160 85.6	DlN$_2$StK 389 94.2	DeN$_1$StK 212 90.5	DeN$_1$ 245 89.8	N$_1$StK 158 88.0	DlP 267 98.7	
	Dl 279 88.5	DlStPK 338 91.1	N$_2$PK 379 91.8	N$_2$K 283 88.7	DeStP 227 88.8	N$_1$P 336 92.2	
NW ↑	DlN$_1$St 332 90.2	DePK 215 89.1	DlN$_1$PK 379 91.7	DeN$_2$P 371 91.5	DlStK 302 91.7	DlN$_2$StPK 344 93.7	
	DlN$_2$P 435 93.0	N$_1$StPK 272 88.6	DeN$_2$StPK 376 91.9	DeN$_1$StPK 294 89.6	DeK 202 87.6	DlN$_1$K 372 92.9	
	DeN$_1$K 309 88.8	N$_1$St 229 83.8	DlPK 297 89.7	DeN$_2$K 339 90.8	St 162 82.1	DeP 258 89.9	
	N$_2$StPK 340 91.0	DlN$_2$StP 466 94.0	DlN$_1$ 337 90.7	DlStP 282 90.8	DeN$_2$StP 350 91.1	DeStK 216 89.6	
	DlN$_1$StPK 403 91.0	N$_1$PK 273 88.6	K 188 85.6	DeN$_1$St 271 89.8	N$_1$StP 270 90.0	DlN$_2$St 384 93.1	
	De 224 88.4	StP 159 83.3	DeN$_2$St 324 91.0	DeN$_1$PK 310 90.0	DlN$_1$P 370 92.6	N$_2$StK 259 89.4	
	DeN$_2$PK 422 92.3	DeN$_1$StP 326 90.8	DeStPK 244 90.2	DlN$_2$PK 460 93.5	DlN$_1$StK 380 92.6	PK 238 87.2	
67	DlN$_2$K 418 91.0	DlSt 276 92.2	N$_2$ 266 89.1	DlK 300 90.8	N$_1$K 224 88.6	N$_2$P 226 83.2	72

System of Replication : 4 randomised blocks of 18 plots each. Certain interactions confounded with block differences.

Area of each Plot (after rejecting edge bouts) : 1/60 acre. Plots actually 1/40 acre (119 lks. × 21 lks.).

Treatments : $3 \times 3 \times 2^3$ factorial design.

Dung : None, 15 tons per acre ploughed in in January (De), or stored and applied in the bouts (Dl).

Straw : None, 40 cwt. per acre (chaffed) (St), ploughed in in January, except when applied with Dl for which straw and dung were mixed and stored.

Sulphate of ammonia : None, 0.4 (N_1). 0.8 (N_2) cwt. N per acre.

Superphosphate : None, 0.8 cwt. P_2O_5 per acre (P).

Sulphate of potash : None, 1.6 cwt. K_2O per acre (K).

Basal Manuring : Nil.

Cultivations, etc. : Dung and chaff applied : Jan. 11. Ploughed : Jan. 15-Feb. 11. Spring tine harrowed : April 13. Cultivated : May 1. Rolled and harrowed : May 3. Cultivated : May 5. Rolled and cultivated : May 6. Rolled and harrowed : May 18. Ridged : May 19. Stored dung applied : May 20. Artificials applied : May 22. Potatoes planted : May 27. Harrowed ridges : June 10. Grubbed and re-ridged : June 12 and 17. Grubbed : July 28. Re-ridged : July 29. Lifted : Oct. 8 and 9. Variety : Ally. Previous crop : Wheat.

Special Note : Potatoes passed through a $1\frac{3}{4}$ inch riddle to determine the percentage ware.

Standard Errors per Plot : Total Produce : 0.845 tons per acre or 10.8%. Percentage ware : 1.81.

Summary of effects of Nitrogenous Fertilizers

Sulph. amm. (cwt. N)	No straw: No Dung	No straw: Dung Ploughed in	No straw: Dung In the bouts	Straw: No Dung	Straw: Dung Ploughed in	Straw: Dung In the bouts
	TOTAL PRODUCE : tons per acre (±0.422)					
0.0	4.96	6.02	7.66	4.21	5.66	8.02
0.4	6.65	7.72	9.76	6.22	7.38	10.07
0.8	7.73	9.74	11.52	7.18	9.36	10.60
	PERCENTAGE WARE (±0.904)					
0.0	85.6	88.8	91.9	84.8	89.3	91.4
0.4	88.8	89.6	92.0	87.6	90.2	91.9
0.8	88.2	91.6	93.3	89.9	92.0	93.8

Main effects : Interactions of Dung

Dung	Sulph. amm. (cwt. N) 0.0	0.4	0.8	Straw (cwt.) 0	40	Super. (cwt. P_2O_5) 0.0	0.8	Sulph. pot. (cwt. K_2O) 0.0	1.6	*Mean*	*Increase*
	TOTAL PRODUCE : tons per acre										
None ..	4.59[1]	6.44	7.46	6.45[2]	5.87	5.40[2]	6.92	5.79[2]	6.52	*6.16*	
Ploughed in	5.84	7.55	9.55	7.83	7.47	7.07	8.22	7.51	7.78	*7.65*	*+1.49*[2]
In the bouts	7.84	9.92	11.06	9.65	9.56	9.33	9.88	9.42	9.79	*9.60*	*+3.44*[2]
Mean ..	*6.09*	*7.97*	*9.36*	*7.98*	*7.63*	*7.27*	*8.34*	*7.57*	*8.03*	*7.80*	
Increase ..		*+1.88*[2]	*+1.39*[2]		*−0.35*[3]		*+1.07*[3]		*+0.46*[3]		
	PERCENTAGE WARE										
None ..	85.2[4]	88.2	89.0	87.5[5]	87.4	86.6[5]	88.3	86.5[5]	88.4	*87.5*	
Ploughed in	89.0	89.9	91.8	90.0	90.5	90.1	90.4	90.1	90.4	*90.2*	*+2.7*[5]
In the bouts	91.7	91.9	93.5	92.4	92.4	92.0	92.8	92.8	92.0	*92.4*	*+4.9*[5]
Mean ..	*88.6*	*90.0*	*91.4*	*90.0*	*90.1*	*89.6*	*90.5*	*89.8*	*90.3*	*90.0*	
Increase ..		*+1.4*[5]	*+1.4*[5]		*+0.1*[6]		*+0.9*[6]		*+0.5*[6]		

St. errors : (1) ±0.299, (2) ±0.244, (3) ±0.199, (4) ±0.639, (5) ±0.522, (6) ±0.426.

Interactions of Sulphate of Ammonia with Straw and Minerals

Sulph. amm. (cwt. N)	Straw (cwt.) 0	40	Super. (cwt. P_2O_5) 0.0	0.8	Sulph. pot. (cwt. K_2O) 0.0	1.6
	TOTAL PRODUCE : tons per acre (±0.244)					
0.0	6.21	5.96	5.81	6.37	5.82	6.36
0.4	8.04	7.89	7.21	8.73	7.93	8.01
0.8	9.66	9.05	8.78	9.93	8.98	9.73
	PERCENTAGE WARE (±0.522)					
0.0	88.8	88.5	88.0	89.3	88.4	88.9
0.4	90.1	89.9	89.3	90.7	89.9	90.1
0.8	91.0	91.9	91.4	91.5	91.1	91.9

Conclusions

Dung increased the yield of total produce by 1.5 tons per acre when ploughed in in January and by 3.4 tons per acre when stored and applied in the bouts, the difference between these two increases being significant.

The double dressing of sulphate of ammonia increased the total produce by 3.3 tons per acre, there being only a slight falling-off in effectiveness at the higher level of application. Straw produced a small but not significant decrease in yield.

Superphosphate increased total produce by 1.1 tons per acre and muriate of potash by 0.5 tons per acre, both increases being significant.

There was a high percentage ware. The effects of the treatments were similar to those on yield, except that straw did not depress the percentage ware.

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SUGAR BEET

Effect of agricultural salt and muriate of potash, ploughed in in December or broadcast in January, April or at sowing, and of dung

RS—Great Knott, 1937

Plan and yields in lb.

Roots (dirty), tops, sugar percentage and plant number in descending order

1	DNa KM$_3$ 653 564 16.50 447	M$_4$ 595 466 15.95 456	M$_2$ 596 488 16.01 453	DNa KM$_1$ 736 577 16.76 482	DNa M$_2$ 808 586 16.50 379	Na M$_4$ 716 642 16.16 432	DNaKM$_1$ 548 494 15.72 289	DNa M$_3$ 663 572 16.24 426	8
	Na M$_1$ 594 476 16.04 381	D KM$_4$ 695 570 16.56 489	DNa M$_2$ 700 542 16.30 503	Na K M$_4$ 686 538 16.88 490	KM$_4$ 625 535 16.13 435	Na M$_1$ 479 508 15.43 407	K M$_1$ 566 450 16.16 424	D KM$_3$ 581 502 15.98 465	
	Na K M$_2$ 708 492 16.56 468	KM$_3$ 672 552 16.42 504	D M$_1$ 651 573 15.87 478	KM$_1$ 520 454 15.52 345	DNa KM$_4$ 655 597 16.13 400	M$_2$ 441 502 15.06 356	D M$_1$ 609 530 16.42 446	D KM$_2$ 592 518 15.75 493	
SW ↑	D M$_3$ 703 534 16.16 495	D Na M$_4$ 749 619 15.58 476	Na M$_3$ 655 539 16.24 424	D K M$_2$ 578 510 16.01 383	M$_3$ 571 519 16.43 420	Na K M$_2$ 667 630 16.16 463	Na K M$_3$ 650 532 16.73 528	D M$_4$ 614 490 15.61 516	
	Na M$_4$ 720 538 16.33 568	K M$_4$ 638 553 15.87 476	D Na M$_3$ 734 596 16.65 493	D M$_2$ 519 520 15.75 340	M$_4$ 502 472 15.90 371	M$_1$ 700 570 16.16 548	D Na K M$_2$ 716 594 16.53 539	Na K M$_4$ 725 593 17.14 550	
	D Na M$_1$ 701 561 16.16 504	Na M$_2$ 708 567 16.13 487	Na K M$_3$ 712 578 16.44 537	D Na K M$_2$ 676 601 16.21 457	D K M$_4$ 508 580 15.49 390	D M$_2$ 699 616 16.47 533	D K M$_1$ 673 577 16.10 506	D Na M$_1$ 630 560 15.03 535	
	M$_1$ 660 476 16.42 534	D K M$_1$ 718 580 16.33 535	D K M$_3$ 728 594 16.82 525	D Na K M$_4$ 731 618 16.50 528	D Na M$_4$ 667 628 15.64 424	Na M$_2$ 643 561 16.56 538	D M$_3$ 682 542 16.42 553	K M$_3$ 621 556 16.30 561	
57	Na K M$_1$ 658 448 16.76 539	K M$_2$ 692 482 16.21 546	D M$_4$ 655 538 16.21 549	M$_3$ 577 466 15.87 512	Na K M$_1$ 498 480 16.47 354	Na M$_3$ 636 555 15.81 482	D Na K M$_3$ 746 643 16.56 544	K M$_2$ 556 536 16.01 511	64

SYSTEM OF REPLICATION: 4 randomised blocks of 16 plots each. Certain interactions partially confounded with block differences.

AREA OF EACH PLOT (after rejecting edge-rows): 3/170 acre. Plots actually 1/50 acre (46.6 lks. × 42.9 lks.).

TREATMENTS: 4×2^3 factorial design.

Dung: None, 10 tons per acre ploughed in in December (D).

Agricultural salt: None, 5 cwt. per acre (NA).

Muriate of potash: None, 1.0 cwt. K_2O per acre (K).

Minerals ploughed in, in December (M_1), broadcast immediately after ploughing (M_2), broadcast in early spring (M_3), broadcast at sowing (M_4).

BASAL MANURING: Sulphate of ammonia at the rate of 0.6 cwt. N per acre, superphosphate at the rate of 0.5 cwt. P_2O_5 per acre.

CULTIVATIONS, ETC.: Dung and minerals (M_1) applied: Dec. 9. Ploughed: Dec. 23-28. Minerals (M_2) applied: Jan. 9. Minerals (M_3) applied: April 3. Cultivated: April 12. Spring tine harrowed: April 13. Tractor rolled and drag harrowed: May 1. Springtine harrowed: May 6. Harrowed and minerals (M_4) applied: May 10. Drilled, harrowed and rolled: May 18. Rolled: May 31. Horse hoed: June 14 and July 19. Singled: June 21-23. Hand hoed: Aug. 5. Lifted: Nov. 29-Dec. 7. Variety: Kleinwanzleben E. Previous crop: Wheat.

STANDARD ERRORS PER PLOT: Total sugar: 5.72 cwt. per acre or 12.5%. Tops: 0.889 tons per acre or 6.45%. Mean dirt tare: 0.135.

Effects of mineral manures

	None	Minerals: Salt	Mur. of pot.	Both	*Mean*	None	Minerals: Salt	Mur. of pot.	Both	*Mean*
	TOTAL SUGAR: cwt. per acre (±2.86)					ROOTS (washed): tons per acre				
M_1 ..	42.8[1]	41.6	44.6	45.0	*43.7*[2]	13.32	13.26	13.88	13.68	*13.61*
M_2 ..		50.9	42.8	48.6	*47.4*[2]		15.54	13.37	14.83	*14.58*
M_3 ..		48.2	48.2	50.6	*49.0*[2]		14.82	14.68	15.26	*14.92*
M_4 ..		49.3	42.0	50.2	*47.2*[2]		15.48	13.07	15.04	*14.53*
Mean	*42.8*[1]	*47.5*[1]	*44.4*[1]	*48.6*[1]	*45.8*	*13.32*	*14.78*	*13.75*	*14.70*	*14.14*
Increase		*+4.7*[3]	*+1.6*[3]	*+5.8*[3]			*+1.46*	*+0.43*	*+1.38*	
	TOPS: tons per acre (±0.444)					SUGAR PERCENTAGE				
M_1 ..	13.12[4]	13.32	13.03	12.64	*13.00*[5]	16.04	15.66	16.03	16.43	*16.04*
M_2 ..		14.27	12.94	14.66	*13.96*[5]		16.37	16.00	16.36	*16.24*
M_3 ..		14.30	13.94	14.66	*14.30*[5]		16.24	16.38	16.56	*16.39*
M_4 ..		15.35	14.16	14.84	*14.78*[5]		15.93	16.01	16.66	*16.20*
Mean	*13.12*[4]	*14.31*[4]	*13.52*[4]	*14.20*[4]	*13.79*	*16.04*	*16.05*	*16.10*	*16.50*	*16.17*
Increase		*+1.19*[6]	*+0.40*[6]	*+1.08*[6]			*+0.01*	*+0.06*	*+0.46*	

Standard Errors: (1) ±1.43, (2) ±1.65, (3) ±2.02, (4) ±0.222, (5) ±0.256, (6) ±0.314.

PLANT NUMBER: thousands per acre

	None	Minerals: Salt	Mur. of pot.	Both	*Mean*
M_1 ..	26.8	25.8	25.6	23.6	*25.0*
M_2 ..		27.0	27.4	27.3	*27.2*
M_3 ..		25.8	29.1	29.2	*28.0*
M_4 ..		26.9	25.4	27.9	*26.7*
Mean	*26.8*	*26.4*	*26.9*	*27.0*	*26.8*
Increase		*−0.4*	*+0.1*	*+0.2*	

M_1 = Minerals ploughed in in December, M_2 = broadcast immediately after ploughing.
M_3 = broadcast in early spring. M_4 = broadcast at sowing.

Effect of dung and interaction of dung with minerals

	Minerals None	Salt	Mur. of pot.	Both	*Mean*	*Increase*
TOTAL SUGAR : cwt. per acre (±2.02)						
No dung	40.5	45.6	43.2	47.6	*44.2*[1]	
Dung	45.2	49.4	45.6	49.5	*47.4*[1]	*+3.2*[2]
TOPS : tons per acre (±0.314)						
No dung	12.52	13.87	13.02	13.57	*13.24*[3]	
Dung	13.73	14.75	14.01	14.83	*14.33*[3]	*+1.09*[4]

	Minerals None	Salt	Mur. of pot.	Both	*Mean*	*Increase*
ROOTS (washed) : tons per acre						
No dung	12.64	14.16	13.38	14.30	*13.62*	
Dung	13.99	15.40	14.11	15.10	*14.65*	*+1.03*
SUGAR PERCENTAGE						
No dung	15.98	16.09	16.08	16.64	*16.20*	
Dung	16.11	16.01	16.13	16.36	*16.15*	*−0.05*

Standard Errors : (1) ±1.01, (2) ±1.43, (3) ±0.157, (4) ±0.222.

PLANT NUMBER : thousands per acre

	Minerals None	Salt	Mur. of pot.	Both	*Mean*	*Increase*
No dung	25.8	26.3	26.9	27.8	*26.7*	
Dung	27.7	26.5	26.8	26.1	*26.8*	*+0.1*

Conclusions

Minerals produced a significant increase in total sugar. The response to salt was 4.4 cwt. per acre as against 1.4 cwt. per acre for muriate of potash, though the difference between the two responses was not significant. The effects on tops were similar. The differences in sugar produced by the different methods of applying the minerals were not significant. In tops, however, the later applications gave significantly higher yields than the earlier applications.

Dung produced significant increases of 3.2 cwt. per acre in sugar and 1.1 tons per acre in tops. The increase in sugar was greater in the absence of potash than in its presence, but not significantly so.

MANGOLDS

Effect of sulphate of ammonia, superphosphate, muriate of potash, agricultural salt and dung

RM—Great Knott, 1937

Plan and yields in lb., roots above, tops centre, plant number below

SW ↑

1	S K D 1168 263 424	P D 908 226 408	S 896 254 407	K Na D 968 266 365	S P 736 252 340	D 804 234 314	S K Na 1204 318 336	K 676 222 285	8
	S P Na D 1208 294 347	P K 836 214 341	Na 824 205 335	S P K Na 1100 276 344	S P K D 776 217 247	P Na 880 248 295	S Na D 1244 298 304	P K Na D 812 264 305	
	Na D 972 286 365	S P Na 1268 300 374	S P K Na D 1252 306 405	S K 848 263 385	S P D 828 244 294	S K Na D 1240 310 369	P K Na 900 244 384	S P K 952 270 397	
25	P K D 876 230 392	P 740 204 386	S D 812 195 363	K Na 728 216 319	Nil 508 166 262	S Na 1108 269 356	P Na 920 248 369	K D 836 232 374	32

SYSTEM OF REPLICATION : 4 randomised block of 8 plots each. Certain high order interactions are partially confounded with block differences.

AREA OF EACH PLOT (after rejecting edge rows) : 0.019444 acre. Plots actually 1/45 acre (48.5 lks. × 45.8 lks.)

TREATMENTS : 2^5 factorial design.

Sulphate of ammonia :	None, 0.6 cwt. N per acre (S).
Superphosphate :	None, 0.5 cwt. P_2O_5 per acre (P).
Muriate of potash :	None, 1.0 cwt. K_2O per acre (K).
Agricultural salt :	None, 5 cwt. per acre (Na).
Dung :	None, 10 tons per acre (D).

BASAL MANURING : Nil.

CULTIVATIONS, ETC. : Dung applied : Dec. 9. Ploughed : Dec. 30 and 31. Cultivated : April 12. Springtine harrowed : April 13 and May 6. Manures applied : May 8. Drilled : May 18. Harrowed : May 18. Rolled : May 18 and 31. Singled : June 29 and 30. Horse hoed : July 20 and Aug. 7. Hand hoed : Aug. 6. Lifted : Oct. 29-Nov. 1. Variety Yellow Globe. Previous crop : Wheat.

STANDARD ERROR PER PLOT : Roots : 1.94 tons per acre or 9.07%.

Response to fertilisers

MEAN YIELDS: Roots: *21.40 tons ;* Tops: *5.77 tons ;* Plant number: *18.0 thousands.*

	Mean response	Differential responses: Sulphate of ammonia Absent	Sulphate of ammonia Present	Dung Absent	Dung Present	Salt Absent	Salt Present	Muriate of potash Absent	Muriate of potash Present	Superphosphate Absent	Superphosphate Present
		ROOTS: tons per acre (±0.970. *Means : ±0.686*)									
Sulphate of ammonia	*+4.95*	—	—	+5.80	+4.11	+2.39	+7.52	+4.43	+5.48	+6.33	+3.58
Dung	*+2.04*	+2.88	+1.19	—	—	+2.34	+1.73	+2.11	+1.96	+3.59	+0.48
Salt	*+4.92*	+2.35	+7.48	+5.22	+4.61	—	—	+6.29	+3.54	+4.99	+4.84
Muriate of potash ..	*+0.74*	+0.22	+1.26	+0.82	+0.66	+2.11	−0.63	—	—	+1.43	+0.05
Superphosphate ..	*+0.22*	+1.60	−1.15	+1.78	−1.33	+0.30	+0.15	+0.92	−0.47	—	—
		TOPS: tons per acre									
Sulphate of ammonia	*+0.90*	—	—	+1.39	+0.41	+0.66	+1.14	+0.83	+0.96	+0.99	+0.81
Dung	*+0.27*	+0.76	−0.22	—	—	−0.02	+0.56	+0.36	+0.19	+0.49	+0.05
Salt	*+0.95*	+0.71	+1.19	+0.67	+1.24	—	—	+1.07	+0.83	+0.98	+0.93
Muriate of potash ..	*+0.27*	+0.20	+0.33	+0.35	+0.18	+0.39	+0.15	—	—	+0.53	+0.01
Superphosphate ..	*+0.06*	+0.14	−0.03	+0.28	−0.17	+0.08	+0.03	+0.31	−0.20	—	—
		PLANT NUMBER: thousands per acre									
Sulphate of ammonia	*+0.6*	—	—	+2.1	−0.9	+0.6	+0.6	+0.3	+0.9	+2.1	−0.9
Dung	*+0.3*	+1.8	−1.2	—	—	+0.1	+0.6	0.0	+0.6	+1.2	−0.6
Salt	*−0.2*	−0.2	−0.2	−0.4	+0.1	—	—	−0.2	−0.1	−0.4	+0.1
Muriate of potash ..	*+0.5*	+0.2	+0.8	+0.2	+0.8	+0.4	+0.5	—	—	+1.0	0.0
Superphosphate ..	*+0.2*	+1.7	−1.3	+1.1	−0.7	−0.1	+0.5	+0.7	−0.3	—	—

Conclusions

Sulphate of ammonia and salt both gave increases of about 4.9 tons per acre in the yield of roots, while dung increased the roots by 2.0 tons per acre. There was also a significant positive interaction between the effects of sulphate of ammonia and salt, the response to each fertiliser being about 7.5 tons in the presence of the other fertiliser and 2.4 tons in its absence.

The responses in roots to muriate of potash and superphosphate were smaller and not significant.

The effects on tops were in general similar to those on roots.

BEANS

Effect of dung, nitro-chalk, superphosphate, muriate of potash and of spacing of the rows

RE—Great Knott, 1937

Plan and yields in lb., grain above, straw below

1	S_1 - - P - 35.3 37.2	S_1 - N - K 34.6 37.9	S_1 D N P - 45.1 47.9	S_1 D - - K 53.7 55.3	4
	S_2 - N - K 36.2 37.3	S_2 - - P - 21.0 24.5	S_2 D N P - 33.4 38.1	S_2 D - - K 40.6 47.9	
	S_2 D N - K 39.3 40.2	S_2 - - - K 20.1 25.4	S_2 - N P - 33.9 36.1	S_2 D - P - 44.0 42.0	
	S_1 D N - K 46.1 48.9	S_1 - N P - 38.4 39.6	S_1 D - P - 46.7 47.8	S_1 - - - K 48.0 47.5	
	S_2 - - P K 35.0 36.5	S_2 D N P K 42.7 39.3	S_2 - N - - 32.4 32.6	S_2 D - - - 29.5 31.0	
	S_1 - N - - 46.7 44.8	S_1 D - - - 49.0 47.0	S_1 D N P K 53.6 51.9	S_1 - - P K 55.1 50.9	
NW ↑	S_1 D - P K 59.1 57.4	S_1 - N P K 50.9 48.6	S_1 - - - - 47.7 42.8	S_1 D N - - 57.3 54.7	
	S_2 D - P K 39.0 42.5	S_2 - N P K 26.8 30.2	S_2 - - - - 16.0 23.5	S_2 D N - - 25.0 31.0	
	S_1 D - P K 47.5 49.5	S_1 D N P - 41.9 44.6	S_1 - N - K 36.5 43.5	S_1 - - - - 33.4 36.1	
	S_2 - - - - 55.6 53.4	S_2 D N P - 44.5 46.5	S_2 D - P K 46.6 46.9	S_2 - N - K 53.6 47.9	
	S_1 D N P K 66.9 67.1	S_1 - - - K 47.5 47.5	S_1 D - P - 48.1 46.9	S_1 - N - - 56.7 55.3	
	S_2 D N P K 52.6 52.4	S_2 D - P - 36.4 39.1	S_2 - N - - 35.4 35.6	S_2 - - - K 30.5 36.5	
	S_1 - - P - 65.9 65.1	S_1 - N P K 52.0 54.0	S_1 D N - - 45.8 49.2	S_1 D - - K 46.3 49.2	
	S_2 - - P - 43.9 45.1	S_2 D N - - 27.9 34.1	S_2 D - - K 26.2 39.8	S_2 - N P K 37.2 36.3	
	S_2 - - P K 42.6 46.9	S_2 D - - - 22.6 30.4	S_2 - N P - 26.4 33.6	S_2 D N - K 29.1 36.4	
61	S_1 - N P - 30.3 44.7	S_1 D - - - 28.3 35.2	S_1 D N - K 28.5 45.0	S_1 - - P K 29.6 39.4	64

SYSTEM OF REPLICATION : 16 randomised blocks of 4 plots each, spacing treatments being applied to blocks of 4 plots. Certain interactions partially confounded with block differences.

AREA OF EACH SUB-PLOT : 1/80 acre (68.7 lks. × 18.2 lks.).

TREATMENTS : 2^5 factorial design.

Spacing : 16 ins. (S_1), 24 ins. (S_2).

Dung : None, 10 tons per acre (D).

Nitro-chalk : None, 0.4 cwt. N per acre (N).

Superphosphate : None, 0.6 cwt. P_2O_5 per acre (P).

Muriate of potash : None, 1.0 cwt. K_2O per acre (K).

BASAL MANURING : Nil.

CULTIVATIONS, ETC. : Dung applied : Nov. 25. Ploughed in beans : Nov. 26. Artificials applied : Dec. 1. Nitro-chalk applied : April 12. Horse hoed : May 5 and 6. Harvested : Aug. 13. Previous crop : Wheat.

STANDARD ERRORS : Grain : per block : 11.9 cwt. per acre or 41.0% ; per plot : 5.34 cwt. per acre or 18.4%.

Responses to treatments

Mean yields : GRAIN, *29.0 cwt.* ; STRAW, *30.7 cwt.*

	Mean response	Differential responses: Spacing 16 ins.	Spacing 24 ins.	Dung Absent	Dung Present	Nitro-chalk Absent	Nitro-chalk Present	Superphosphate Absent	Superphosphate Present	Muriate of potash Absent	Muriate of potash Present
	GRAIN : cwt. per acre (±1.89. *Means : ±1.34*)										
Spacing 24 ins.-16 ins. ..	*−7.7*[1]	—	—	−7.2[2]	−8.2[2]	−8.5[2]	−6.9[2]	−8.3[2]	−7.2[2]	−8.4[2]	−7.0[2]
Dung	*+2.0*	+2.5	+1.4	—	—	+1.6	+2.3	+1.6[3]	+2.4[3]	+0.3	+3.6
Nitro-chalk ..	*+0.4*	−0.4	+1.2	0.0	+0.7	—	—	+1.6	−0.9	−0.1	+0.8
Superphosphate	*+3.3*	+2.7	+3.8	+2.9[3]	+3.7[3]	+4.5	+2.0	—	—	+1.3[3]	+5.3[3]
Mur. pot. ..	*+2.4*	+1.8	+3.1	+0.8	+4.1	+2.0	+2.9	+0.4[3]	+4.3[3]	—	—
	STRAW : cwt. per acre										
Spacing 24 ins.-16ins. ..	*−7.0*	—	—	−6.8	−7.1	−6.4	−7.6	−7.0	−7.0	−7.2	−6.7
Dung	*+2.6*	+2.8	+2.5	—	—	+2.2	+3.1	+2.7	+2.6	+0.7	+4.6
Nitro-chalk ..	*+0.4*	+1.0	−0.2	0.0	+0.9	—	—	+1.2	−0.3	+1.0	−0.1
Superphosphate	*+2.4*	+2.3	+2.4	+2.5	+2.4	+3.1	+1.6	—	—	+1.9	+2.9
Mur. pot. ..	*+2.7*	+2.4	+2.9	+0.7	+4.6	+3.2	+2.2	+2.2	+3.1	—	—

Standard errors : (1) ± 2.97, (2) ±4.20, (3) ±2.67.

Conclusions

Superphosphate produced a significant increase in yield of grain of 3.3 cwt. per acre. The increases in grain produced by dung and muriate of potash were not significant, while the response to nitro-chalk was negligible.

In half the blocks the rows were spaced 16 inches apart and in the other half 24 inches apart. The narrow spacing gave 7.7 cwt. of grain per acre more than the wide spacing, the difference being significant.

KALE

Effect of sulphate of ammonia, poultry manure, soot and rape dust

RK—FOSTER'S, 1937 (4th year)

Plan and yields in lb.

1	R_1 327	N_2 429	M_2 294	M_1 278	M_0 177	R_1 180	R_0 163	N_1 277	8
SW ↑	S_2 340	S_1 263	N_1 293	M_0 211	S_0 169	M_1 191	M_2 231	N_2 389	
	R_0 261	S_0 209	R_2 363	N_0 216	R_2 384	S_2 312	N_0 144	S_1 231	
	R_0 217	N_2 418	M_1 216	S_1 236	R_0 185	R_2 287	R_1 185	M_1 236	
	N_0 203	M_2 268	M_0 216	S_0 216	M_0 145	N_2 372	N_1 233	S_2 301	
41	R_1 235	S_2 330	R_2 337	N_1 289	S_0 140	N_0 195	S_1 165	M_2 261	48

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

AREA OF EACH PLOT (after rejecting edge rows) : 0.025712 acre. Plots actually 0.028926 acre (14 yds. × 10 yds.)

TREATMENTS, 1937 : No nitrogen ($_0$), 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 in seed-bed at the rate of 0.4 cwt. N per acre ($_1$), or 0.8 cwt. N per acre ($_2$). Plots receiving treatment ($_0$) in 1937 had treatment ($_2$) in 1936 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 fertilizer symbols refer to the 1936 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 : March 8-10. Spring tine harrowed : April 9. Manures applied : April 27. Applied first half of sulphate of ammonia : April 29. Rolled and harrowed : May 3. Seed sown : May 4. Rolled and harrowed : May 4. Horse hoed : June 3 and 21. Applied second half of sulphate of ammonia : July 2. Horse hoed : July 19. Hand hoed : July 29. Harvested : Jan. 5 and 15. Variety : Thousand head. Previous crop : Kale. (See 1936 Report, p. 223.)

STANDARD ERROR PER PLOT : 0.436 tons per acre or 9.86%.

Summary of Results : tons per acre (±0.218)

Nitrogen, cwt. per acre 1934 1936	1935 1937	Sulph. amm.	Poultry manure	Soot	Rape dust	*Mean (±0.109)*
0.8	0.0	3.29	3.25	3.19	3.59	*3.33*
0.4	0.4	4.74	4.00	3.88	4.02	*4.16*
0.0	0.8	6.98	4.58	5.57	5.95	*5.77*
Mean (±0.126)		*5.00*	*3.94*	*4.21*	*4.52*	*4.42*

Conclusions

The crop of kale was a poor one. The 1937 dressings produced significant increases in yield, the yield with the double dressing of sulphate of ammonia being significantly above that with any other types of fertilizer, while poultry manure gave a significantly lower yield than soot or rape dust.

There was no indication of any differences in the residual effects of the fertilizers.

SUGAR BEET

WOBURN

Effect of agricultural salt and of muriate of potash, ploughed in in December or broadcast in December, early in March or at sowing, and of dung

WS—Butt Furlong, 1937

Plan and yields in lb.

					Roots (dirty)	Tops	Sugar per cent.	Plant number					Roots (dirty)	Tops	Sugar per cent.	Plant number	
1	—	—	—	M_1	541	332	16.46	460	D	Na	—	M_3	576	416	16.73	482	33
	—	Na	—	M_2	531	357	16.85	470	D	—	—	M_1	557	361	17.14	487	
	D	Na	—	M_1	609	433	16.68	482	—	—	—	M_2	513	312	16.93	495	
	—	Na	K	M_3	599	384	17.31	474	—	Na	K	M_3	546	305	17.45	509	
	—	—	K	M_2	621	422	16.01	464	—	Na	—	M_1	541	268	16.73	504	
	D	Na	—	M_3	652	489	16.70	450	D	—	K	M_3	575	304	17.08	488	
	D	—	K	M_1	642	433	16.68	476	—	Na	K	M_2	523	259	17.60	483	
	D	—	—	M_2	590	377	14.92	476	D	Na	K	M_4	544	331	18.20	495	
	D	—	K	M_3	607	419	16.79	486	—	Na	—	M_1	498	238	17.94	497	
	—	—	K	M_4	585	351	17.51	484	D	Na	—	M_2	560	276	18.92	485	
	D	Na	K	M_2	591	361	17.42	494	D	—	—	M_3	488	243	18.23	478	
W ↑	D	Na	K	M_4	612	393	17.45	495	—	—	—	M_4	439	238	17.74	506	
	D	—	—	M_4	530	287	17.74	496	—	Na	—	M_3	499	296	17.77	478	
	—	—	—	M_3	476	238	17.25	488	D	Na	K	M_1	518	318	17.28	498	
	—	Na	K	M_1	501	214	17.63	489	—	Na	K	M_2	505	269	18.35	500	
	—	Na	—	M_4	488	242	17.77	489	D	—	K	M_2	511	308	17.14	498	
	D	—	—	M_3	524	257	17.63	498	—	—	K	M_1	501	394	15.95	493	
	D	Na	—	M_4	544	279	18.03	482	D	—	—	M_4	595	432	16.01	480	
	—	Na	K	M_4	483	230	18.10	467	D	Na	K	M_1	584	432	16.56	485	
	D	—	K	M_4	505	271	17.45	497	—	Na	—	M_4	544	356	16.91	495	
	—	Na	—	M_3	468	267	17.51	495	D	Na	—	M_2	634	389	16.79	481	
	D	Na	—	M_1	516	297	17.16	481	D	—	K	M_2	589	345	16.84	467	
	D	—	K	M_1	520	276	17.68	482	—	—	K	M_4	552	338	17.37	487	
	D	—	—	M_2	539	314	17.22	482	—	—	—	M_3	553	326	17.51	481	
	—	—	K	M_3	491	245	17.45	455	—	—	—	M_2	553	320	17.74	503	
	D	Na	K	M_2	510	288	17.86	456	D	—	K	M_4	570	383	17.34	499	
	—	Na	—	M_2	477	270	17.19	466	D	—	—	M_1	559	307	17.48	473	
	—	Na	K	M_1	517	236	16.70	464	—	—	K	M_3	573	327	18.09	493	
	D	Na	K	M_3	468	329	18.95	472	D	Na	K	M_3	609	479	16.68	487	
	—	—	K	M_2	454	288	18.46	460	D	Na	—	M_4	616	458	16.47	478	
	—	—	—	M_1	460	299	18.49	474	—	Na	K	M_4	556	311	17.94	459	
32	—	—	—	M_4	471	311	18.20	476	—	—	K	M_1	579	338	17.88	479	64

The positions of the blocks in the field were slightly different from those shown above.

SYSTEM OF REPLICATION : 4 randomised blocks of 16 plots each. Certain interactions partially confounded with block differences.

AREA OF EACH PLOT (after rejecting edge rows) : 3/220 acre. Plots actually 1/55 acre (99.9 lks. × 18.2 lks.).

TREATMENTS : 4 × 2^3 factorial design.

Dung : None, 10 tons per acre ploughed in, in November (D).

Agricultural salt : None, 5 cwt. per acre (Na).

Muriate of potash : None, 1.0 cwt. K_2O per acre (K).

Minerals ploughed in, in December (M_1), broadcast immediately after ploughing (M_2), broadcast in early spring (M_3), broadcast at sowing (M_4).

BASAL MANURING : Sulphate of ammonia at the rate of 0.6 cwt. N per acre, superphosphate at the rate of 0.5 cwt. P_2O_5 per acre.

CULTIVATIONS, ETC. : Dung applied : Nov. 30. Minerals (M_1) applied : Dec. 2-4. Ploughed and minerals (M_2) applied : Dec. 4-6. Minerals (M_3) applied : Mar. 12. Harrowed : April 28. Drilled and minerals (M_4) applied : April 30. Harrowed : May 1. Rolled : May 5. Hand hoed : May 17-20. Singled : May 28-June 2. Hand hoed : June 22-24. Lifted : Oct. 29-Nov. 20. Variety : Kleinwanzleben E. Previous crop : Potatoes.

STANDARD ERRORS PER PLOT : Total Sugar : 4.05 cwt. per acre or 7.29%. Tops : 1.65 tons per acre or 15.4%. Mean dirt tare : 0.095.

Effects of mineral manures

TOTAL SUGAR : cwt. per acre (±2.02)

	None	Minerals Salt	Mur. of pot.	Both	*Mean*
M_1 ..	53.3[1]	53.8	56.5	54.0	*54.8*[2]
M_2 ..		57.2	56.1	56.5	*56.6*[2]
M_3 ..		54.5	58.0	57.4	*56.6*[2]
M_4 ..		56.2	57.4	58.4	*57.3*[2]
Mean ..	*53.3*[1]	*55.4*[1]	*57.0*[1]	*56.6*[1]	*55.6*
Increase ..		*+2.1*[3]	*+3.7*[3]	*+3.3*[3]	

ROOTS (washed) : tons per acre

	None	Minerals Salt	Mur. of pot.	Both	*Mean*
M_1 ..	15.46	15.72	16.55	15.86	*16.04*
M_2 ..		16.42	16.52	15.88	*16.27*
M_3 ..		15.91	16.72	16.38	*16.34*
M_4 ..		16.30	16.48	16.32	*16.37*
Mean ..	*15.46*	*16.09*	*16.57*	*16.11*	*16.06*
Increase ..		*+0.63*	*+1.11*	*+0.65*	

TOPS : tons per acre (±0.825)

	None	Minerals Salt	Mur. of pot.	Both	*Mean*
M_1 ..	10.14[4]	10.12	11.80	9.82	*10.58*[5]
M_2 ..		10.57	11.16	9.63	*10.45*[5]
M_3 ..		12.01	10.60	12.26	*11.62*[5]
M_4 ..		10.92	11.00	10.36	*10.76*[5]
Mean ..	*10.14*[4]	*10.90*[4]	*11.14*[4]	*10.52*[4]	*10.68*
Increase ..		*+0.76*[6]	*+1.00*[6]	*+0.38*[6]	

SUGAR PERCENTAGE

	None	Minerals Salt	Mur. of pot.	Both	*Mean*
M_1 ..	17.29	17.13	17.05	17.04	*17.07*
M_2 ..		17.44	17.11	17.81	*17.45*
M_3 ..		17.18	17.35	17.60	*17.38*
M_4 ..		17.30	17.42	17.92	*17.55*
Mean ..	*17.29*	*17.26*	*17.23*	*17.59*	*17.34*
Increase ..		*−0.03*	*−0.06*	*+0.30*	

Standard errors : (1) ±1.01, (2) ±1.17, (3) ± 1.43, (4) ±0.413, (5) ±0.476, (6) ±0.583.

PLANT NUMBER : thousands per acre

	None	Minerals Salt	Mur. of pot.	Both	*Mean*
M_1 ..	35.5	36.0	35.4	35.4	*35.6*
M_2 ..		34.8	34.6	35.4	*34.9*
M_3 ..		35.0	35.2	35.6	*35.3*
M_4 ..		35.6	36.0	35.2	*35.6*
Mean ..	*35.5*	*35.4*	*35.3*	*35.4*	*35.4*
Increase ..		*−0.1*	*−0.2*	*−0.1*	

M_1=Minerals ploughed in, in December ; M_2=broadcast immediately after ploughing M_3=broadcast in early spring ; M_4=broadcast at sowing.

Effect of dung and interaction of dung with minerals

TOTAL SUGAR : cwt. per acre (±1.43)

	None	Minerals Salt	Mur. of pot.	Both	*Mean*	*Increase*
No dung	52.2	51.4	56.7	55.8	*54.0*[1]	
Dung	54.4	59.5	57.3	57.4	*57.2*[1]	*+ 3.2*[2]

ROOTS (washed) : tons per acre

	None	Minerals Salt	Mur. of pot.	Both	*Mean*	*Increase*
No dung	14.90	14.82	16.38	15.82	*15.48*	
Dung	16.01	17.36	16.75	16.40	*16.63*	*+1.15*

TOPS : tons per acre (±0.583)

	None	Minerals Salt	Mur. of pot.	Both	*Mean*	*Increase*
No dung	9.72	9.38	11.06	9.04	*9.80*[3]	
Dung	10.55	12.42	11.21	12.00	*11.54*[3]	*+1.74*[4]

SUGAR PERCENTAGE

	None	Minerals Salt	Mur. of pot.	Both	*Mean*	*Increase*
No dung	17.54	17.33	17.34	17.64	*17.46*	
Dung	17.05	17.18	17.12	17.55	*17.22*	*−0.24*

Stnadard errors : (1) ±0.715, (2) ±1.01, (3) ±0.292, (4) ±0.413.

PLANT NUMBER : thousands per acre

	None	Minerals Salt	Mur. of pot.	Both	*Mean*	*Increase*
No dung	35.6	35.7	35.0	35.2	*35.4*	
Dung	35.5	35.0	35.7	35.6	*35.4*	*0.0*

Conclusions

The yields of total sugar were high. The average response to minerals was significant in both total sugar and tops. In both cases the response to muriate of potash was somewhat greater than that to salt, though the differences were not significant. The differences produced by the different methods of applying the minerals were not significant.

Dung produced significant increases of 3.2 cwt. per acre in sugar and 1.7 tons per acre in tops.

KALE

WOBURN

Effect of sulphate of ammonia, poultry manure, soot and rape dust

WK—LANSOME, 1937 (4th year)

Plan and yields in lb.

1	S_1 81.4	N_2 129.8	R_1 88.0	N_1 110.0	S_0 71.5	R_1* 83.6	R_0 70.4	S_2 108.9	8
	R_0 71.5	N_0 68.2	M_0 61.6	S_0 59.4	N_0 74.8	M_2 95.7	S_1 78.1	M_1 71.5	
NW ↑	S_2 83.6	M_2 89.1	R_2 75.9	M_1 79.2	N_2 138.6	R_2 103.4	N_1 96.8	M_0 64.9	
	S_1 71.5	M_0 62.7	M_2 82.5	M_1 78.1	N_2 157.3	M_1 73.7	R_0 71.5	S_0 58.3	
	R_0 58.3	N_2 138.6	N_0 62.7	S_0 61.6	N_0 67.1	S_2 113.3	M_2 90.2	R_2 91.3	
41	N_1 77.0	R_2 79.2	S_2 107.8	R_1 78.1	S_1 77.0	M_0 57.2	N_1 95.7	R_1 85.8	48

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

AREA OF EACH PLOT : 1/160 acre (25 lks. × 25 lks.).

TREATMENTS, 1937 : No nitrogen ($_0$) 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 in seed-bed at the rate of 0.4 cwt. N per acre ($_1$) or 0.8 cwt. N per acre ($_2$). Plots receiving treatment ($_0$) in 1937 had treatment ($_2$) in 1936 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 fertilizer symbols refer to the 1936 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 : Feb. 12 and 13. Rolled and harrowed : May 7. Manures applied (sulphate of ammonia at half rate) : May 8. Seed sown : May 8. Singled : June 17-21. Second half of sulphate of ammonia applied: July 8. Hoed : June 21 and July 8-10. Harvested : Jan. 24, 26, 28, and 31. Variety : Thousand head. Previous crop : Kale (see 1936 Report p. 229.)

STANDARD ERROR PER PLOT : 0.562 tons per acre or 9.32%.

Summary of Results: tons per acre (±0.281)

Nitrogen, cwt. per acre 1934 1936	1935 1937	Sulph. amm.	Poultry manure	Soot	Rape dust	*Mean* (*±0.140*)
0.8	0.0	4.87	4.40	4.48	4.85	*4.65*
0.4	0.4	6.78	5.40	5.50	5.99	*5.92*
0.0	0.8	10.08	6.38	7.39	6.25	*7.52*
Mean (*±0.162*)		*7.24*	*5.39*	*5.79*	*5.70*	*6.03*

Conclusions

The crop was a small one and very tough in the stalk. The fertilizers applied in 1937 produced significant increases in yield, sulphate of ammonia giving significantly higher yields than any of the other fertilizers.

There was no indication of any differences in the residual effects of the 1936 applications.

PYRETHRUM

WOBURN

The effect of lime, fish manure and artificial fertilisers on the yield of flowers and their content of Pyrethrins

ROADPIECE, 1937 (5th year)

Plan and yields—Pyrethrin I content per cent. 1935, total Pyrethrins per cent. 1935, dry stalkless heads 1937 (grammes), Pyrethrin I content per cent. 1937, total Pyrethrins per cent. 1937, in descending order

1 | 8

NW ↑

LOA1 0.57 1.21 —	**LFO2** 0.53 1.21 —	**OFO2** 0.48 1.11 —	**LOO1** 0.50 1.20 —	**OOA1** 0.43 0.99 —	**LOO1** 0.45 1.04 —	**OOA2** 0.51 1.18 —	**OOO2** 0.43 1.00 —
LFO1 0.50 1.09 1007 0.53 1.23	**OOA2** 0.42 0.98 948 0.51 1.14	**OOA1** 0.44 1.03 959 0.48 1.22	**OFA2** 0.53 1.07 1724 0.56 1.28	**OFO1** 0.42 0.93 1217 0.50 1.23	**LOA2** 0.46 0.99 1361 0.62 1.34	**LOA1** 0.54 1.20 1262 0.53 1.26	**LFA1** 0.46 0.98 883 0.52 1.16
LFA2 0.47 1.03 1530 0.51 1.25	**OFO1** 0.44 1.01 1208 0.51 1.14	**LFA1** 0.49 1.14 1559 0.51 1.22	**LOA2** 0.42 0.95 1615 0.58 1.32	**LFO1** 0.42 0.97 1272 0.48 1.23	**LOO2** 0.43 0.92 1349 0.57 1.29	**LFO2** 0.44 0.99 1556 0.56 1.25	**OFA2** 0.43 0.99 1279 0.55 1.28
OOO1 0.42 0.93 —	**LOO2** 0.46 0.92 —	**OOO2** 0.42 0.93 —	**OFA1** 0.45 0.98 —	**OFA1** 0.42 1.02 —	**LFA2** 0.42 0.98 —	**OOO1** 0.57 1.12 —	**OFO2** 0.37 0.83 —

25 | 32

Notes: In 1937 the outside plots on the NW and SE sides were omitted from the experiment, owing to poor yields in previous years. The 1935 pyrethrin analyses were done too late for inclusion in the 1935 Report and are given above for completeness.

SYSTEM OF REPLICATION : 2 randomised blocks of 8 plots each.

AREA OF EACH PLOT (after rejecting edge rows) : 0.00560 acre. Plots actually 29.6 lks. × 22.7 lks.

TREATMENTS :

Lime : None (O), 2.88 tons equivalent to 4 tons $CaCO_3$ applied in first year only (L).

Fish manure : None (O), 5 cwt. per acre (0.4 cwt. N) applied in first year only, half this dressing applied every year (F).

Complete artificals : None (O), sulphate of ammonia (0.4 cwt. N), superphosphate (0.4 cwt. P_2O_5) and muriate of potash (0.5 cwt. K_2O) applied in first year only, half this dressing applied every year (A).

Manures applied : 1st year only 1933(1), every year (2).

CULTIVATIONS, ETC. : Hand hoed : Aug. 9-15, 1936. Weeded: April, 1937. Manures applied : April 14. Harvested : June 28-29. Previous crop : Pyrethrum (see 1936 Report, p. 231).

SPECIAL NOTE : The residual effects of the artificials and fish manure applied in the first year of he experiment were assumed to be negligible.

STANDARD ERRORS PER PLOT : Dry stalkless heads : 0.867 cwt. per acre or 17.8%.
Pyrethrin I content per cent. : 0.0327.

Effect of Lime

	No Lime	Lime	*Increase*	Standard error
Dry stalkless heads, cwt. ..	4.26	4.86	*+0.60*	±0.450
Pyrethrin I content, per cent. ..	0.520	0.545	*+0.025*	±0.018
Total pyrethrins, per cent. ..	1.23	1.25	*+0.02*	—

Effect of artificials and fish manures, applied every year

	None	Artificials	Fish manure	Artificials and fish manure	*Mean of manures*	*Increase*
Dry stalkless heads, cwt.	4.17	4.58	5.25	5.49	*5.11*	*+0.94*
Pyrethrin I content, per cent	0.51	0.57	0.55	0.55	*0.56*	*+0.05*
Total pyrethrins, per cent.	1.22	1.27	1.24	1.27	*1.26*	*+0.05*

No single standard error can be applied to the figures in the same line of this table.

Conclusions

Lime applied in 1933 increased both the yield of heads and the pyrethrin I content, though neither increase was significant. Manures applied every year produced significant increases in both heads and pyrethrin I content. The increase in heads was somewhat greater with fish manure than with artificials, though not significantly so.

EXPERIMENTS ON POULTRY MANURE

Centres.	Type of Experiment	No. of plots	Year
Rothamsted (see pp. 164 for details)	2aCR	48	4
Woburn (see pp. 167 for details)	2aCR	48	4
Lady Manner's School, Bakewell (A)	1C	16	4
Lady Manner's School, Bakewell (B)	1C	16	4
Grammar School, Burford	1C	16	4
St. Joseph's School, Castleford, Yorks	1C	16	2
Fakenham Secondary School, Norfolk	1C	16	4
County School, Godalming, Surrey	1C	16	4
Sailors' Orphan Homes School, Newlands, Hull	1C	16	4
A. G. Brightman, Esq., Maulden (A), Beds. J. W. Dallas, Esq., County Organiser	2R	24	2
A. G. Brightman, Esq., Maulden (B), Beds. J. W. Dallas, Esq., County Organiser	3	24	3
Norton New Council School, Doncaster, Yorks	1C	16	2
Council School, Oxted, Surrey	1	16	1
L. Pope, Esq., Pelton, Durham	1C	12	3
J. Martland, Ltd., Rufford, Ormskirk. J. J. Green, Esq., County Organiser	2CR	24	2
Church of England School, Staindrop, Darlington, Co. Durham	1C	16	4
J. W. Bonner, Esq., Steppingly, Beds. J. W. Dallas, Esq., County Organiser	2CR	24	4
County School, Welshpool, Montgomeryshire	1C	16	4
R. S. Maudlin, Esq., Wyboston. J. W. Dallas, Esq., County Organiser	2R	24	4

Experimental arrangements

(1) 2^2 factorial design. P.M, S/A.
4 × 4 Latin squares or randomised blocks.
* Basal manuring : 1.0 cwt. K_2O and 0.8 cwt. P_2O_5 per acre.

(1C) Cumulative : As (1) with treatments repeated on the same plots each year.

(2CR) Immediate, cumulative and residual effects. Manures S/A (S) and P.M. (M). Treatments as follows :

1st year	O	O	1S	1M	2S	2M
2nd year	2S	2M	1S	1M	O	O
3rd year	O	O	1S	1M	2S	2M
4th year	2S	2M	1S	1M	O	O

Randomised blocks.
* Basal manuring : 1.0 cwt. K_2O and 1.0 cwt. P_2O_5 per acre.

(2aCR) As (2CR) with soot.

(2R) As (2CR) for the first two years, but with no treatments in the third and fourth years.

(3) Immediate, cumulative and residual effects. Treatments as follows :

1st year	O	O	M	M	O	O	S	S
2nd year	O	M	O	M	O	S	O	S
3rd year	M	M	O	O	S	S	O	O
4th year	M	O	M	O	S	O	S	O

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.

(1), (1C): N at the rate of O, 0.6 and 1.2 cwt. per acre.
(2CR), (2R): N at the rate of O, 0.4 and 0.8 cwt. per acre.
(3): N at the rate of O and 0.6 cwt. per acre.

Place	Crop	Area Acres	Soil	Variety	Manures applied	Seed sown	Harvested	Previous Crop
Bakewell (A)	Potatoes	1/102	Limestone	Gladstone	May 7-11	May 7-11	Oct. 11-15	Ryegrass
Bakewell (B)	Ryegrass	1/102	Limestone	Westernwolths	June 4-9	June 11	Aug. 19	Mangolds
Burford	Potatoes	1/120	Limestone loam	Great Scot	April 22-28	April 12-15	Sept. 20-22	Swedes
Castleford	Potatoes	1/100	Heavy loam	Majestic & Great Scot	April 27-May 13	April 28-May 14	Oct. 5-27	Potatoes
Fakenham	Carrots	1/302	Sandy loam	James Scarlet Intermediate	May 10-11	May 17-19	Oct. 4-15	Peas
Godalming	Potatoes	1/239	Sandy	Red King	—	May 8	Aug. 10-11	
Hull	Cabbages	1/161	Heavy Alluvium	Utility	June 16	June 14	Oct.-Jan.	Swedes
Maulden (A)	Kale	1/73	Brown sand	Green Curled	—	July 20	Mar. 19-April 21	Potatoes
Maulden (B)	Runner Beans	1/75	Brown sand	Emperor	May 27	June 12	Aug. 27-Oct. 22	Potatoes
Norton	Cabbages	1/237	Light loam	Winningstadt	May 25	May 31	Sept.-Oct.	Potatoes
Oxted	Potatoes	1/161	Gault Clay	King Edward	May 24	May 31	Oct. 1	Potatoes
Pelton	Swedes	1/186	Medium loam	Perfection	April 30	May 3-4	Sept. 28-29	Beet
Rufford	Potatoes	1/80	Light loam	Arran Banner	April	April 23	Nov. 4	Potatoes
Staindrop	Potatoes	1/160	Good loam	Great Scot	April 29	April 29	Sept. 15	Swedes
Steppingley	Potatoes	1/50	Brown sand	Epicure	April 8	April 9	July 29	Runner Beans
Welshpool	Potatoes	1/160	Medium loam	Arran Banner	May 8	May 15	Oct. 12-20	Swedes
Wyboston	Clover	1/50	Silty Gravel	Broad Red	April 2, 1935	Spring 1936	June 24	Wheat

Cumulative Experiments Types 1 and 1C

Year of experiment	Place	Crop	No. N.	P.M.	S/A	S/A and P.M.	*Mean*	St. error
First	Oxted	Potatoes : tons per acre	2.58	2.32	3.02	3.20	*2.78*	±0.236
	Castleford	Potatoes : tons per acre	5.68	6.18	6.70	6.83	*6.35*	±0.216
Second	Norton	Cabbages, Saleable : tons per acre	10.52	16.31	12.91	15.50	*13.81*	±0.260
		Cabbages, Saleable %	76.8	93.7	84.8	94.6	*87.5*	±3.68
Third	Pelton	Swedes, roots : tons per acre	12.50	13.32	13.82	15.05	*13.67*	±1.21
		tops : tons per acre	4.54	4.92	5.41	5.75	*5.16*	±0.182
Fourth	Burford	Potatoes : tons per acre	6.36	6.74	6.04	6.54	*6.42*	±0.258
	Staindrop	Potatoes : tons per acre	3.90	6.45	8.89	9.58	*7.20*	±0.244
	Welshpool	Potatoes : tons per acre	8.11	11.09	10.00	11.80	*10.25*	±0.188
	Godalming	Potatoes : tons per acre	5.16	6.59	7.04	6.89	*6.42*	±0.245
	Bakewell (A)	Potatoes : tons per acre	5.86	5.72	6.69	6.88	*6.29*	±0.251
	Staindrop	Potatoes : percentage ware	93.5	95.1	96.4	96.9	*95.5*	±0.285
	Hull	Cabbages : tons per acre	11.14	13.75	12.66	13.54	*12.77*	±0.314
	Fakenham	Carrots, roots and tops : tons per acre	11.15	9.66	6.88	6.27	*8.49*	±0.630
	Bakewell (B)	Ryegrass (green) : tons per acre	7.45	7.96	7.77	8.24	*7.86*	±0.162

The standard errors apply to individual entries in the tables.

Conclusions

Poultry manure and sulphate of ammonia alone and in combination.

In the first-year experiment on potatoes at Oxted, sulphate of ammonia produced a significant increase on a poor crop, while poultry manure had no appreciable effect.

At Castleford, sulphate of ammonia gave a larger response in potatoes than poultry manure, though the difference did not reach significance.

In the fourth-year cumulative experiments on potatoes, there were significant responses to nitrogen at all centres except Burford. At Staindrop the responses in total produce were large for both sulphate of ammonia and poultry manure. Sulphate of ammonia gave significantly greater responses than poultry manure in both total produce and percentage ware. Sulphate of ammonia also proved superior to poultry manure at Godalming, though not significantly so, and at Bakewell (A), where poultry manure produced no response. At Welshpool, on the other hand, the response to poultry manure was significantly greater than that to sulphate of ammonia.

There were good responses to nitrogen in saleable cabbages at Doncaster, poultry manure giving a significantly greater response than sulphate of ammonia. Similar results were obtained for the percentage of saleable cabbages, except that the superiority of poultry manure over sulphate of ammonia was not significant. The results in the fourth-year experiment on cabbages at Hull were also similar, poultry manure proving significantly better than sulphate of ammonia. At Pelton, the response to nitrogen was significant in swedes tops but not in roots. In both cases sulphate of ammonia gave higher yields than poultry manure, but not significantly so.

At Fakenham, nitrogen produced a striking depression in the yields of carrots. The yields with sulphate of ammonia were significantly below those with poultry manure.

There was a significant increase to nitrogen in ryegrass at Bakewell, but the responses to the two forms did not differ significantly.

Experiments on residual effects

Type 2 R

Place	Crop	Treatments 1934	1935	1936 and 1937	P.M.	S/A	*Mean*	St. error
Wyboston	Clover hay: cwt. per acre (±2.25)	2N	ON	ON	70.2	69.1	*69.6*	
		1N	1N	ON	65.7	65.3	*65.5*	±1.59
		ON	2N	ON	74.1	70.4	*72.2*	
		Mean (±1.30)			*70.0*	*68.3*	*69.1*	
		1935	1936	1936-7				
Maulden (A)	Kale: tons per acre (±0.931)	O	O	O	5.61[1]		*5.61*	
		N	O	O	7.72	5.57	*6.64*	
		O	N	O	7.33	5.63	*6.48*	±0.658
		N	N	O	6.38	5.55	*5.96*	
		Mean (±0.538)			7.14	5.58	*6.17*	

Standard error: (1) ±0.658.

Conclusions

Residual Effects

There were no significant differences in the residual effects on red clover at Wyboston, though the plots which had previously received poultry manure gave somewhat better yields than those which had previously received sulphate of ammonia.

At Maulden (A), kale was grown as an unmanured catch crop following the 1936 crop of potatoes. There were indications of a residual effect of poultry manure, though this was not quite significant. There was no sign of a residual effect of sulphate of ammonia.

Experiments on immediate, cumulative and residual effects

Type 2 CR

Place	Year of experiment	Crop	1934 and 1936 / 1935 and 1937	2N / ON	1N / 1N	ON / 2N	*Mean*	St.error
Rufford	Second	Potatoes: tons per acre (±0.326)	PM	2.48	3.08	3.37	*2.98*	±0.188
			S/A	2.25	3.47	4.00	*3.24*	
			Mean (±0.231)	*2.36*	*3.28*	*3.68*	*3.11*	
Steppingley	Fourth	Potatoes: tons per acre (±0.262)	PM	2.23	3.10	3.94	*3.09*	±0.151
			S/A	1.79	2.54	3.38	*2.57*	
			Mean (±0.185)	*2.01*	*2.82*	*3.66*	*2.83*	

Conclusions

Immediate, cumulative and residual effects

At Rufford the potato crop was attacked by eelworm and the yields were poor. There were significant responses to the direct application of nitrogen, sulphate of ammonia giving higher yields than poultry manure, though the difference was not significant. The difference between the residual effects, if any, of poultry manure and sulphate of ammonia was small and not significant. In the fourth year experiment at Steppingley there were good responses to nitrogen in early potatoes. Poultry manure gave higher yields than sulphate of ammonia in all three types of application, the average difference being significant.

Experiments on immediate, cumulative and residual effects

Type 3

Place	Crop	1935 / 1936 / 1937		N O O	N N O	O O N	O N N	*Mean*	
Maulden	Runner Beans : cwt. per acre	Pickings 1-3	PM	45.1	44.4	41.3	50.2	*45.2*	
			S/A	43.1	46.2	42.9	46.9	*44.8*	
		Pickings 4-6	PM	35.7	34.4	28.1	44.4	*35.6*	
			S/A	31.3	33.3	38.2	40.4	*35.8*	
		Pickings 7-9	PM	12.7	13.2	9.8	15.2	*12.7*	
			S/A	11.4	10.7	13.6	14.1	*12.4*	
	(±3.98)	Total	PM	93.5	92.0	79.2	109.8	*93.6*	±1.99
			S/A	85.8	90.2	94.7	101.4	*93.0*	
		Mean (±*2.81*)		*89.6*	*91.1*	*87.0*	*105.6*	*93.3*	

Conclusions

Immediate, cumulative and residual effects

The direct application of sulphate of ammonia produced a significant increase in total produce. The residual effects of the previous year's dressing were not significant. The direct effects of poultry manure were irregular, the plots receiving poultry manure for the first time this year giving anomalously low yields. On plots receiving manures this year, sulphate of ammonia gave slightly but not significantly higher yields than poultry manure, while on plots receiving no manure this year, the previous application of poultry manure gave slightly higher yields than the previous application of sulphate of ammonia.

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.

AREA OF EACH PLOT: Poppleton II: 1/50 acre. Bardney II and Wissington III: 1/80 acre. Wissington II and Rothamsted I*: 1/100 acre. Tunstall: 1/120 acre. Remainder: 1/40 acre.

TREATMENTS: 3 × 3 × 3 factorial design.
Sulphate of ammonia: None, 0.4 cwt., 0.8 cwt. N per acre.
Superphosphate: None, 0.5 cwt., 1.0 cwt. P_2O_5 per acre.
Muriate of Potash: None, 0.6 cwt., 1.2 cwt. K_2O per acre.

VARIETIES: Brigg I: Johnson's P. Kidderminster I: Kuhn. Spalding: Kuhn P. King's Lynn II: Sharpes. Ely: Dippe W.I. Remainder: Kleinwanzleben E.

Mechanical and chemical analyses of soil samples from each experiment have been carried out.
* Area harvested: 1/250 acre.

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
COARSE SANDS				
1 Allscott I	15.88	23.0	20.0	1.55
2 Bardney II	10.59	30.3	18.0	0.783
3 Brigg II	13.77	22.3	20.0	1.38
4 Bury I	10.30	27.8	20.0	0.830
5 Cantley I	10.21	33.8	18.0	0.677
6 Tunstall	7.50	56.7	21.0	0.296
7 Wissington II	13.00	26.1	18.0	1.12
FINE SANDS				
8 Brigg I	14.41	24.0	19.0	1.34
9 Bury II	10.36	22.8	21.0	1.02
10 Ipswich	10.66	30.4	19.0	0.785
11 Kidderminster I	11.17	25.7	21.0	0.974
12 King's Lynn II	12.45	27.8	20.0	1.00
13 Spalding	17.48	38.4	18.0	1.02
LIGHT LOAMS				
14 Allscott II	6.51	18.8	20.0	0.776
15 Bardney I	13.84	30.5	18.0	1.02
16 Cantley II	12.56	21.6	20.0	1.30
17 King's Lynn I	10.70	27.4	18.0	0.875
18 Newark I	13.67	31.0	18.0	0.988
19 Peterboro' I	7.13	22.9	19.5	0.697
20 Poppleton I	11.56	26.5	22.5	0.977
21 Poppleton II	11.72	24.1	22.5	1.09
22 Selby I	9.63	26.6	20.0	0.811
23 Wissington III	13.28	31.0	18.0	0.960
HEAVY LOAM				
24 Colwick	14.56	32.8	18.0	0.994
CLAY LOAMS				
25 Felstead I	9.78	23.8	22.5	0.920
26 Felstead II	11.53	25.7	22.5	1.00
27 Rothamsted I	12.01	31.3	20.0	0.860
28 Selby II	10.05	27.2	20.0	0.828
FENS				
29 Ely	11.39	33.6	21.0	0.759
30 Peterboro' II	11.59	24.7	19.5	1.05

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	Station	Soil	Previous crop	Date of sowing	Date of lifting	Farming notes
1	Allscott I ..	Light sandy loam	Potatoes	April 30	Nov. 9-10	Dung and 1 ton limestone for beet.
2	Bardney II ..	Coarse sandy loam	Wheat	May 4	Nov. 9-10	Late summer too dry.
3	Brigg II ..	Coarse sandy loam	Wheat	May 4	Dec. 1	
4	Bury I ..	Sandy	Clover	April 21	Dec. 2	Poor plant, game and wind damage.
5	Cantley I ..	Light sandy loam	Barley	April 23	Nov. 3-4	Late summer drought. Badly singled.
6	Tunstall ..	Medium fine sand	Rye	May 25*	Nov. 12	Storm washed, redrilled, too many plants left.
7	Wissington II	Poor sandy loam	Wheat	April 5	Oct. 26	
8	Brigg I ..	Coarse sandy loam	Wheat	May 18	Nov. 29	
9	Bury II ..	Light sandy loam	Oats	April 27	Oct. 25	" Beet tailings " ploughed in for beet.
10	Ipswich ..	Loam with coarse sand	Wheat	May 6	Nov. 23-30	Dung for beet.
11	Kidderminster I	Light sandy loam	Barley	April 26	Nov. 3-6	Slight aphis attack, drought in September.
12	King's Lynn II	Light sandy loam	Barley	May 11	Nov. 17	Dung for beet.
13	Spalding ..	Deep silt	Wheat	April 30	Oct. 19	Very good land. Dung for beet.
14	Allscott II ..	Light sandy loam	Oats	April 24, 26	Nov. 3	Dung and 8 cwt. lime for beet, very poor plant.
15	Bardney I ..	Coarse sandy loam	Barley	April 28	Nov. 9-10	
16	Cantley II ..	Fine sandy loam	Wheat	May 6	Dec. 6	Some wireworm damage.
17	King's Lynn I	Light sandy loam	Barley	May 6	Nov. 18	Damage by heavy rain in June.
18	Newark I ..	Light loam	Wheat	April 30	Dec. 10	Damaged by hail in July. All plots slagged before sampling.
19	Peterboro' I ..	Medium loam	Barley	April 23	Oct. 20	Dung for beet.
20	Poppleton I ..	Light sandy loam	Potatoes	May 5	Nov. 10-12	
21	Poppleton II	Light sandy loam	Wheat	May 6	Nov. 16-17	
22	Selby I ..	Light warp	Wheat	May 25*	Oct. 14-15	
23	Wissington III	Medium sandy loam	Barley	May 11	Nov. 15	
24	Colwick ..	Sandy loam	Potatoes	April 27	Nov. 8-10	Wireworm and aphis damage.
25	Felstead I ..	Sandy clay loam	Wheat	May 8	Oct. 14	
26	Felstead II ..	Clay loam	Oats	May 18	Nov. 13	Dung for beet.
27	Rothamsted I	Clay loam	Wheat	May 18	Nov. 24	
28	Selby II ..	Heavy warp	Wheat	May 19	Oct. 5-7	Factory "lime" for beet, very uneven plant.
29	Ely	Light fen	Wheat	May 6	Nov. 4-11	
30	Peterboro' II	Heavy fen	Wheat	May 6	Dec. 7	Dung for beet, partly flooded.

*Second sowing

Sampling errors in sampling for sugar content

(10 *roots in each sample*)

Station	No. of Samples analysed per plot	Standard error per sample
5 Cantley I	2	0.237
7 Wissington II	4	0.322
23 Wissington III	4	0.317

Significant Responses

	N	P	K
Total sugar (30)	+*	+*	+*
Tops (24)	+*	+*	+
		Curvature	
Total sugar ..	—	0	0
Tops	0	0	0
	N×P	N×K	P×K
Total sugar ..	0	+	0
Tops	0	0	0

Symbols

+ = Positive, 0 = No, — = negative } Significant Average Response

(30) No. of centres

* = Significant differences between centres

Mean Responses per 1 *cwt. of* N, P_2O_5 *and* K_2O

	N Average 1933-36	N 1937	P Average 1933-36	P 1937	K Average 1933-36	K 1937
Total Sugar—cwt.	+4.4	+6.5	+1.3	+1.9	+1.0	+2.3
Roots—tons ..	+1.59	+2.12	+0.36	+0.55	+0.18	+0.55
Tops—tons ..	+3.40	+3.75	+0.38	+0.56	+0.09	+0.34
Sugar %	−0.60	−0.39	+0.02	0.00	+0.22	+0.22
Plant number ..	+0.4	+0.4	+0.5	+0.3	+0.3	+0.6
Purity %	−0.7	0.0	+0.3	+0.1	+0.1	+0.3

M

Main Effects and First Order Interactions

Total Sugar : cwt. per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
1	N_0	48.8	50.8	46.2	51.0	46.5	48.3	*48.6*	K_0	52.4	50.0	52.8
	N_1	50.0	51.9	55.8	50.8	52.1	54.8	*52.6*	K_1	48.2	53.1	50.7
	N_2	51.9	52.7	55.0	53.5	53.5	52.6	*53.2*	K_2	50.0	52.3	53.4
	Mean	*50.2*	*51.8*	*52.3*	*51.7*	*50.7*	*51.9*	*51.4*	±2.14. *Means* : ±*1.24*			
2	N_0	31.9	33.2	33.4	31.9	34.9	31.8	*32.9*	K_0	34.4	34.6	37.3
	N_1	35.6	38.8	42.5	38.6	39.7	38.6	*39.0*	K_1	35.5	37.7	39.2
	N_2	36.6	39.3	40.6	35.8	37.9	42.9	*38.8*	K_2	34.2	39.0	40.1
	Mean	*34.7*	*37.1*	*38.9*	*35.4*	*37.5*	*37.8*	*36.9*	±2.10. *Means* : ±*1.21*			
3	N_0	42.7	41.2	40.8	38.5	43.0	43.1	*41.5*	K_0	42.1	50.7	47.9
	N_1	47.0	47.5	47.1	49.4	44.1	48.1	*47.2*	K_1	45.2	45.1	45.5
	N_2	48.5	49.9	53.3	52.7	48.7	50.3	*50.6*	K_2	50.9	42.8	47.9
	Mean	*46.1*	*46.2*	*47.1*	*46.9*	*45.3*	*47.2*	*46.4*	±2.74. *Means* : ±*1.58*			
4	N_0	28.5	27.7	28.4	24.8	28.1	31.8	*28.2*	K_0	23.8	31.5	31.0
	N_1	33.8	39.2	39.1	32.1	40.8	39.3	*37.4*	K_1	35.8	36.0	36.3
	N_2	31.9	40.3	37.7	29.4	39.2	41.3	*36.6*	K_2	34.7	39.7	37.9
	Mean	*31.4*	*35.7*	*35.1*	*28.8*	*36.0*	*37.5*	*34.1*	±2.30. *Means* : ±*1.33*			
5	N_0	31.1	34.2	30.0	30.3	32.2	32.8	*31.8*	K_0	29.1	32.8	33.4
	N_1	33.4	34.0	38.1	33.1	37.0	35.4	*35.2*	K_1	36.5	37.7	34.7
	N_2	38.9	36.1	33.4	32.0	39.7	36.8	*36.2*	K_2	37.8	33.8	33.3
	Mean	*34.5*	*34.8*	*33.8*	*31.8*	*36.3*	*35.0*	*34.4*	±2.44. *Means* : ±*1.41*			
	N_0	19.8	20.3	23.4	18.3	22.1	23.1	*21.2*	K_0	22.5	20.3	22.7
	N_1	28.7	26.3	27.4	22.8	28.1	31.5	*27.5*	K_1	27.2	27.8	25.8
	N_2	30.5	28.5	27.0	24.4	30.5	31.1	*28.7*	K_2	29.4	27.0	29.3
	Mean	*26.4*	*25.0*	*25.9*	*21.8*	*26.9*	*28.6*	*25.8*	±1.28. *Means* : ±*0.739*			
7	N_0	40.7	39.8	37.7	35.2	40.7	42.2	*39.4*	K_0	42.8	42.3	42.7
	N_1	45.1	46.1	51.7	44.5	46.9	51.6	*47.6*	K_1	45.8	43.3	45.1
	N_2	49.0	51.7	47.9	48.2	46.7	53.7	*49.5*	K_2	46.2	51.9	49.5
	Mean	*44.9*	*45.8*	*45.8*	*42.6*	*44.7*	*49.2*	*45.5*	±2.12. *Means* : ±*1.22*			
8	N_0	44.9	46.9	45.2	45.0	46.9	45.1	*45.7*	K_0	48.8	49.4	49.6
	N_1	50.4	50.7	52.3	50.9	50.7	51.8	*51.1*	K_1	49.3	49.0	51.7
	N_2	52.5	51.5	54.5	51.9	52.4	54.2	*52.8*	K_2	49.6	50.8	50.7
	Mean	*49.3*	*49.7*	*50.7*	*49.3*	*50.0*	*50.4*	*49.9*	±1.31. *Means* : ±*0.756*			
9	N_0	34.8	36.3	33.0	36.5	35.2	32.3	*34.7*	K_0	38.5	35.1	37.3
	N_1	36.3	35.3	40.5	38.4	34.7	39.0	*37.4*	K_1	38.5	34.9	37.2
	N_2	40.6	36.9	40.2	36.1	40.7	40.9	*39.2*	K_2	34.7	38.4	39.1
	Mean	*37.2*	*36.2*	*37.9*	*37.0*	*36.9*	*37.4*	*37.1*	±2.09. *Means* : ±*1.21*			
10	N_0	37.1	32.7	33.7	29.2	36.9	37.3	*34.5*	K_0	29.3	31.5	32.4
	N_1	35.6	34.9	32.8	30.9	33.0	39.3	*34.4*	K_1	39.0	34.8	34.0
	N_2	34.3	35.4	36.3	33.1	37.8	35.2	*35.4*	K_2	38.8	36.7	36.3
	Mean	*35.7*	*34.3*	*34.3*	*31.1*	*35.9*	*37.3*	*34.8*	±1.85. *Means* : ±*1.07*			

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Total Sugar: cwt. per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
11	N_0	33.4	33.3	36.0	30.1	34.4	38.2	*34.2*	K_0	30.9	34.4	37.0
	N_1	31.0	45.3	42.0	34.9	37.4	46.0	*39.4*	K_1	33.0	38.1	39.4
	N_2	40.1	36.4	41.3	37.3	38.8	41.8	*39.3*	K_2	40.6	42.5	42.9
	Mean	*34.8*	*38.3*	*39.8*	*34.1*	*36.8*	*42.0*	*37.6*	±2.82. *Means* : ±*1.63*			
12	N_0	38.5	41.5	39.3	38.1	41.7	39.5	*39.8*	K_0	44.4	43.3	43.7
	N_1	43.2	45.5	47.0	43.7	44.9	47.1	*45.2*	K_1	41.9	43.3	46.3
	N_2	49.6	45.6	50.7	49.6	45.0	51.3	*48.6*	K_2	45.0	45.9	47.0
	Mean	*43.8*	*44.2*	*45.7*	*43.8*	*43.9*	*46.0*	*44.6*	±2.30. *Means* : ±*1.33*			
13	N_0	60.4	59.5	56.2	57.8	58.4	59.9	*58.7*	K_0	53.7	59.7	57.1
	N_1	54.4	60.0	59.9	54.9	59.1	60.2	*58.1*	K_1	57.6	59.0	59.3
	N_2	57.3	59.7	57.6	57.9	58.5	58.1	*58.2*	K_2	60.6	60.4	57.2
	Mean	*57.3*	*59.7*	*57.9*	*56.8*	*58.7*	*59.4*	*58.3*	±2.00. *Means* : ±*1.15*			
14	N_0	9.8	21.1	29.7	15.3	24.5	20.9	*20.2*	K_0	9.0	21.2	23.8
	N_1	9.8	27.4	26.9	20.3	19.3	24.5	*21.4*	K_1	10.9	24.4	24.3
	N_2	13.0	29.4	25.2	18.4	15.8	33.4	*22.5*	K_2	12.8	32.3	33.6
	Mean	*10.9*	*26.0*	*27.3*	*18.0*	*19.9*	*26.3*	*21.4*	±3.93. *Means* : ±*2.27*			
15	N_0	48.3	43.8	46.5	44.2	46.9	47.6	*46.2*	K_0	52.6	48.0	47.1
	N_1	49.1	51.7	47.7	52.4	46.8	49.3	*49.5*	K_1	49.6	48.3	48.9
	N_2	52.5	54.8	51.8	51.1	53.1	54.9	*53.0*	K_2	47.8	54.1	49.9
	Mean	*50.0*	*50.1*	*48.7*	*49.2*	*48.9*	*50.6*	*49.6*	±2.67. *Means* : ±*1.54*			
16	N_0	41.5	39.8	44.3	41.7	41.4	42.4	*41.8*	K_0	40.4	43.2	42.3
	N_1	43.4	42.6	42.4	42.1	42.0	44.3	*42.8*	K_1	46.7	39.1	42.8
	N_2	48.4	45.3	42.1	42.1	45.2	48.6	*45.3*	K_2	46.2	45.4	43.7
	Mean	*44.4*	*42.6*	*42.9*	*42.0*	*42.9*	*45.1*	*43.3*	±1.84. *Means* : ±*1.06*			
17	N_0	33.3	31.1	36.3	33.2	31.7	35.7	*33.5*	K_0	34.8	39.5	38.5
	N_1	32.7	43.7	38.1	36.9	40.9	36.8	*38.2*	K_1	34.8	41.8	39.8
	N_2	41.1	43.9	44.8	42.7	43.9	43.2	*43.3*	K_2	37.5	37.4	40.9
	Mean	*35.7*	*39.6*	*39.7*	*37.6*	*38.8*	*38.6*	*38.3*	±2.52. *Means* : ±*1.45*			
18	N_0	45.2	44.0	47.6	44.1	44.8	47.8	*45.6*	K_0	45.6	49.8	50.2
	N_1	47.2	50.3	50.9	47.5	50.7	50.2	*49.5*	K_1	50.2	47.9	50.1
	N_2	55.1	54.4	52.1	53.9	52.7	55.0	*53.9*	K_2	51.7	51.1	50.1
	Mean	*49.2*	*49.6*	*50.2*	*48.5*	*49.4*	*51.0*	*49.7*	±1.78. *Means* : ±*1.03*			
19	N_0	25.4	31.6	32.3	29.1	33.2	27.0	*29.8*	K_0	25.4	30.3	27.6
	N_1	24.5	32.0	28.5	27.9	30.1	27.0	*28.3*	K_1	26.7	31.6	33.5
	N_2	26.2	30.1	31.1	26.2	28.6	32.5	*29.1*	K_2	23.9	31.8	30.8
	Mean	*25.4*	*31.2*	*30.6*	*27.8*	*30.6*	*28.8*	*29.1*	±2.08. *Means* : ±*1.20*			
20	N_0	32.7	39.2	37.5	37.7	39.6	32.1	*36.5*	K_0	36.8	34.7	36.3
	N_1	39.6	41.5	40.0	34.1	38.3	48.7	*40.4*	K_1	39.5	38.5	38.5
	N_2	39.3	34.8	40.0	36.0	38.6	39.5	*38.0*	K_2	35.3	42.4	42.6
	Mean	*37.2*	*38.5*	*39.2*	*35.9*	*38.8*	*40.1*	*38.3*	±3.33. *Means* : ±*1.92*			

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Total Sugar: cwt. per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
21	N_0	36.7	36.7	36.9	36.8	37.2	36.3	*36.8*	K_0	40.5	41.5	39.5
	N_1	42.2	39.9	39.9	41.6	41.3	39.1	*40.7*	K_1	40.9	40.2	40.2
	N_2	40.3	43.8	45.9	43.0	42.8	44.1	*43.3*	K_2	37.8	38.8	43.0
	Mean	*39.7*	*40.2*	*40.9*	*40.5*	*40.4*	*39.9*	*40.3*	±1.74. *Means* : ±*1.00*			
22	N_0	32.0	30.3	32.5	30.5	31.4	32.9	*31.6*	K_0	30.7	30.5	32.7
	N_1	29.2	33.4	32.8	31.1	33.8	30.5	*31.8*	K_1	33.0	33.8	33.9
	N_2	34.4	32.0	37.7	32.3	35.5	36.3	*34.7*	K_2	31.9	31.5	36.3
	Mean	*31.9*	*31.9*	*34.3*	*31.3*	*33.6*	*33.2*	*32.7*	±2.28. *Means* : ±*1.32*			
23	N_0	41.5	42.2	38.1	39.1	41.5	41.2	*40.6*	K_0	48.5	47.3	44.4
	N_1	45.4	49.8	51.2	49.4	49.4	47.5	*48.8*	K_1	47.1	49.5	48.9
	N_2	55.1	52.8	52.0	51.6	54.6	53.7	*53.3*	K_2	46.4	48.0	48.0
	Mean	*47.3*	*48.3*	*47.1*	*46.7*	*48.5*	*47.5*	*47.6*	±1.82. *Means* : ±*1.05*			
24	N_0	49.8	48.7	49.5	48.1	50.7	49.2	*49.3*	K_0	48.5	51.7	53.2
	N_1	51.0	51.6	55.5	51.1	55.0	52.0	*52.7*	K_1	51.8	52.7	54.3
	N_2	52.1	54.3	54.9	54.1	53.0	54.2	*53.8*	K_2	52.7	50.2	52.4
	Mean	*51.0*	*51.5*	*53.3*	*51.1*	*52.9*	*51.8*	*51.9*	±1.55. *Means* : ±*0.895*			
25	N_0	31.7	33.1	33.1	35.6	31.2	31.2	*32.6*	K_0	35.4	39.8	40.8
	N_1	36.5	39.9	39.2	38.3	39.0	38.2	*38.5*	K_1	36.4	38.8	39.2
	N_2	41.2	43.0	45.5	42.0	44.2	43.4	*43.2*	K_2	37.6	37.4	37.8
	Mean	*36.5*	*38.7*	*39.3*	*38.6*	*38.1*	*37.6*	*38.1*	±1.31. *Means* : ±*0.756*			
26	N_0	38.5	34.9	35.8	32.7	38.5	37.9	*36.4*	K_0	40.1	38.9	43.3
	N_1	43.0	38.2	46.3	43.2	42.0	42.3	*42.5*	K_1	43.4	37.3	44.1
	N_2	44.1	44.9	47.9	46.4	44.3	46.2	*45.6*	K_2	42.0	41.7	42.6
	Mean	*41.9*	*39.3*	*43.3*	*40.8*	*41.6*	*42.1*	*41.5*	±2.21. *Means* : ±*1.28*			
27	N_0	33.5	37.3	36.3	36.2	36.0	34.9	*35.7*	K_0	35.4	38.2	40.0
	N_1	39.0	42.4	39.2	38.6	41.5	40.6	*40.2*	K_1	35.6	43.6	35.1
	N_2	38.1	41.4	41.7	38.7	36.9	45.7	*40.4*	K_2	39.7	39.4	42.2
	Mean	*36.9*	*40.4*	*39.1*	*37.9*	*38.1*	*40.4*	*38.8*	±2.94. *Means* : ±*1.70*			
28	N_0	36.4	35.7	34.4	32.7	37.7	36.1	*35.5*	K_0	36.6	36.1	34.1
	N_1	39.1	36.1	37.8	36.2	38.8	38.0	*37.7*	K_1	38.4	38.2	36.3
	N_2	38.5	38.7	34.6	37.8	36.3	37.7	*37.3*	K_2	39.1	36.3	36.4
	Mean	*38.0*	*36.8*	*35.6*	*35.6*	*37.6*	*37.3*	*36.8*	±1.52. *Means* : ±*0.878*			
29	N_0	38.3	37.9	38.5	37.0	39.1	38.7	*38.2*	K_0	37.0	38.4	36.1
	N_1	40.1	40.9	41.2	40.9	41.0	40.3	*40.7*	K_1	37.7	39.2	40.3
	N_2	34.5	34.9	35.8	33.6	37.1	34.5	*35.1*	K_2	38.3	36.1	39.1
	Mean	*37.6*	*37.9*	*38.5*	*37.2*	*39.1*	*37.8*	*38.0*	±1.89. *Means* : ±*1.09*			
30	N_0	36.9	41.8	34.2	39.0	32.2	41.7	*37.6*	K_0	34.5	35.7	37.1
	N_1	35.3	37.0	36.6	36.6	31.5	40.8	*36.3*	K_1	28.8	35.8	31.2
	N_2	32.0	37.8	36.3	31.7	32.2	42.2	*35.4*	K_2	40.9	45.1	38.8
	Mean	*34.7*	*38.9*	*35.7*	*35.8*	*31.9*	*41.6*	*36.4*	±2.66. *Means* : ±*1.54*			

Roots (washed) : tons per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
1	N_0	15.13	15.47	13.99	15.59	14.27	14.74	*14.87*	K_0	16.24	15.11	16.25
	N_1	15.39	16.03	17.34	15.51	16.21	17.04	*16.25*	K_1	14.99	16.67	15.55
	N_2	16.25	16.28	17.00	16.50	16.72	16.30	*16.51*	K_2	15.53	16.01	16.53
	Mean	*15.59*	*15.93*	*16.11*	*15.87*	*15.74*	*16.03*	*15.88*				
2	N_0	8.99	9.43	9.49	9.04	9.99	8.87	*9.30*	K_0	10.16	10.09	10.70
	N_1	10.37	11.10	11.89	11.35	11.27	10.74	*11.12*	K_1	10.30	10.91	11.01
	N_2	10.76	11.63	11.63	10.56	10.97	12.49	*11.34*	K_2	9.66	11.15	11.29
	Mean	*10.04*	*10.72*	*11.00*	*10.32*	*10.74*	*10.70*	*10.59*				
3	N_0	12.53	12.23	11.98	11.40	12.61	12.72	*12.24*	K_0	12.71	15.18	14.13
	N_1	14.15	14.01	13.67	14.78	12.94	14.11	*13.94*	K_1	13.48	13.39	13.25
	N_2	14.38	15.09	15.91	15.84	14.57	14.97	*15.13*	K_2	14.87	12.75	14.17
	Mean	*13.69*	*13.77*	*13.85*	*14.01*	*13.37*	*13.93*	*13.77*				
4	N_0	8.56	8.31	8.49	7.43	8.49	9.44	*8.45*	K_0	7.28	9.58	9.52
	N_1	10.15	11.60	11.58	9.74	11.99	11.61	*11.11*	K_1	10.86	10.70	10.94
	N_2	9.88	12.34	11.82	9.21	12.03	12.81	*11.35*	K_2	10.45	11.97	11.43
	Mean	*9.53*	*10.75*	*10.63*	*8.79*	*10.83*	*11.29*	*10.30*				
5	N_0	9.27	9.74	8.85	8.99	9.40	9.47	*9.29*	K_0	8.92	9.94	10.17
	N_1	10.00	10.12	11.24	10.17	10.97	10.22	*10.45*	K_1	10.73	11.07	10.34
	N_2	11.52	10.96	10.16	9.88	11.77	10.99	*10.88*	K_2	11.13	9.81	9.73
	Mean	*10.26*	*10.27*	*10.08*	*9.68*	*10.71*	*10.23*	*10.21*				
6	N_0	5.68	5.82	6.64	5.39	6.23	6.52	*6.05*	K_0	6.82	6.27	6.86
	N_1	8.16	7.57	7.93	6.91	7.98	8.77	*7.89*	K_1	7.80	7.98	7.38
	N_2	9.11	8.50	8.11	7.64	8.95	9.12	*8.57*	K_2	8.32	7.64	8.45
	Mean	*7.65*	*7.30*	*7.56*	*6.65*	*7.72*	*8.14*	*7.50*				
7	N_0	11.45	11.24	10.61	10.08	11.47	11.75	*11.10*	K_0	12.37	12.19	12.50
	N_1	12.88	13.12	14.62	12.81	13.34	14.46	*13.54*	K_1	13.14	12.32	13.01
	N_2	14.24	14.77	14.11	14.18	13.67	15.27	*14.37*	K_2	13.05	14.61	13.82
	Mean	*12.85*	*13.04*	*13.11*	*12.35*	*12.83*	*13.83*	*13.00*				
8	N_0	12.95	13.29	13.04	13.19	13.37	12.73	*13.10*	K_0	14.16	14.42	14.78
	N_1	14.37	14.40	15.09	14.68	14.33	14.85	*14.62*	K_1	14.28	13.90	14.84
	N_2	15.26	15.12	16.13	15.49	15.32	15.69	*15.50*	K_2	14.14	14.50	14.64
	Mean	*14.19*	*14.27*	*14.75*	*14.45*	*14.34*	*14.43*	*14.41*				
9	N_0	9.55	10.22	9.28	10.24	9.91	8.90	*9.68*	K_0	10.91	9.94	10.65
	N_1	10.08	9.74	11.50	10.67	9.76	10.88	*10.44*	K_1	10.45	9.78	10.51
	N_2	11.28	10.31	11.29	10.60	11.07	11.21	*10.96*	K_2	9.55	10.54	10.90
	Mean	*10.30*	*10.09*	*10.69*	*10.50*	*10.25*	*10.33*	*10.36*				
10	N_0	11.12	9.79	9.95	8.85	10.79	11.22	*10.29*	K_0	8.95	9.82	9.81
	N_1	10.75	10.57	10.32	9.48	10.30	11.86	*10.55*	K_1	11.79	10.66	10.54
	N_2	10.78	11.11	11.52	10.25	11.90	11.26	*11.14*	K_2	11.90	11.00	11.45
	Mean	*10.88*	*10.49*	*10.60*	*9.53*	*11.00*	*11.45*	*10.66*				

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Roots (washed): tons per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
11	N_0	9.73	9.73	10.36	9.03	9.91	10.88	*9.94*	K_0	9.35	10.44	11.10
	N_1	9.25	13.42	12.35	10.41	11.26	13.35	*11.67*	K_1	9.79	11.28	11.85
	N_2	12.00	11.08	12.62	11.45	11.75	12.51	*11.90*	K_2	11.83	12.51	12.39
	Mean	*10.32*	*11.41*	*11.78*	*10.30*	*10.97*	*12.24*	*11.17*				
12	N_0	10.85	11.44	11.11	10.61	11.70	11.09	*11.13*	K_0	12.41	12.03	12.25
	N_1	12.13	12.47	13.04	12.07	12.44	13.14	*12.55*	K_1	11.86	11.89	13.04
	N_2	13.98	12.86	14.13	14.01	12.65	14.31	*13.66*	K_2	12.70	12.84	12.99
	Mean	*12.32*	*12.26*	*12.76*	*12.23*	*12.26*	*12.85*	*12.45*				
13	N_0	17.47	17.83	16.91	17.11	17.80	17.31	*17.41*	K_0	16.53	18.04	17.22
	N_1	16.23	17.69	17.78	16.63	17.49	17.58	*17.23*	K_1	17.13	17.66	18.19
	N_2	17.48	18.17	17.75	18.04	17.69	17.67	*17.80*	K_2	17.52	17.99	17.03
	Mean	*17.06*	*17.90*	*17.48*	*17.26*	*17.66*	*17.52*	*17.48*				
14	N_0	3.08	6.40	8.86	4.74	7.38	6.23	*6.11*	K_0	2.93	6.62	7.23
	N_1	3.13	8.18	8.20	6.29	5.90	7.32	*6.50*	K_1	3.45	7.47	7.38
	N_2	4.18	9.00	7.57	5.74	5.03	9.98	*6.92*	K_2	4.02	9.50	10.02
	Mean	*3.46*	*7.86*	*8.21*	*5.59*	*6.10*	*7.84*	*6.51*				
15	N_0	13.30	12.04	12.94	12.18	12.92	13.17	*12.76*	K_0	14.63	13.43	13.31
	N_1	13.66	14.28	13.49	14.79	13.09	13.55	*13.81*	K_1	13.84	13.55	13.58
	N_2	14.86	15.54	14.41	14.40	14.95	15.46	*14.94*	K_2	13.36	14.87	13.95
	Mean	*13.94*	*13.95*	*13.61*	*13.79*	*13.66*	*14.06*	*13.84*				
16	N_0	11.98	11.44	12.47	11.92	11.83	12.13	*11.96*	K_0	12.01	12.36	12.10
	N_1	12.58	12.27	12.13	12.14	11.98	12.87	*12.33*	K_1	13.23	11.40	12.53
	N_2	14.03	13.39	12.75	12.41	13.34	14.43	*13.39*	K_2	13.35	13.35	12.72
	Mean	*12.86*	*12.37*	*12.45*	*12.16*	*12.38*	*13.14*	*12.56*				
17	N_0	9.43	8.70	10.16	9.28	8.97	10.05	*9.43*	K_0	9.79	10.86	10.69
	N_1	9.20	12.03	10.65	10.16	11.39	10.33	*10.63*	K_1	9.81	11.61	11.13
	N_2	11.42	12.28	12.41	11.90	12.19	12.03	*12.04*	K_2	10.46	10.55	11.40
	Mean	*10.02*	*11.01*	*11.07*	*10.45*	*10.85*	*10.80*	*10.70*				
18	N_0	12.26	12.26	12.98	11.96	12.48	13.06	*12.50*	K_0	12.51	13.76	14.00
	N_1	12.99	14.02	13.96	13.29	13.94	13.75	*13.66*	K_1	13.86	13.41	13.71
	N_2	15.03	15.14	14.40	15.01	14.56	15.00	*14.86*	K_2	13.92	14.27	13.62
	Mean	*13.43*	*13.81*	*13.78*	*13.42*	*13.66*	*13.94*	*13.67*				
19	N_0	6.24	7.88	8.19	7.25	8.24	6.81	*7.43*	K_0	6.20	7.33	6.76
	N_1	5.98	7.75	7.03	6.70	7.44	6.62	*6.92*	K_1	6.48	7.76	8.38
	N_2	6.29	7.27	7.59	6.35	6.93	7.87	*7.05*	K_2	5.82	7.82	7.66
	Mean	*6.17*	*7.63*	*7.60*	*6.76*	*7.54*	*7.10*	*7.13*				
20	N_0	9.72	12.08	11.10	11.20	11.89	9.81	*10.97*	K_0	11.25	10.69	10.89
	N_1	12.18	12.52	11.86	10.66	11.52	14.37	*12.19*	K_1	11.78	11.67	11.54
	N_2	11.76	10.61	12.18	10.98	11.57	12.00	*11.52*	K_2	10.63	12.85	12.70
	Mean	*11.22*	*11.74*	*11.71*	*10.95*	*11.66*	*12.06*	*11.56*				

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Roots (washed) : tons per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
21	N_0	10.48	10.80	10.47	10.41	10.89	10.45	*10.58*	K_0	11.77	12.06	11.29
	N_1	12.16	11.57	11.74	11.99	11.87	11.60	*11.82*	K_1	12.07	11.95	11.57
	N_2	12.01	13.01	13.28	12.71	12.83	12.76	*12.77*	K_2	10.80	11.37	12.64
	Mean	*11.55*	*11.79*	*11.83*	*11.70*	*11.86*	*11.60*	*11.72*				
22	N_0	9.29	9.11	9.45	8.96	9.36	9.53	*9.28*	K_0	8.95	9.11	9.89
	N_1	8.70	9.84	9.64	9.14	10.13	8.90	*9.39*	K_1	9.87	10.22	9.85
	N_2	10.27	9.87	10.47	9.84	10.44	10.32	*10.20*	K_2	9.44	9.49	9.82
	Mean	*9.42*	*9.61*	*9.85*	*9.32*	*9.98*	*9.58*	*9.63*				
23	N_0	11.30	11.67	10.52	10.85	11.30	11.34	*11.16*	K_0	13.63	13.41	12.42
	N_1	12.64	13.94	14.23	13.85	13.75	13.21	*13.60*	K_1	13.19	13.61	13.63
	N_2	15.69	14.93	14.63	14.76	15.36	15.13	*15.08*	K_2	12.82	13.52	13.33
	Mean	*13.21*	*13.51*	*13.13*	*13.15*	*13.47*	*13.22*	*13.28*				
24	N_0	13.79	13.60	13.73	13.31	14.13	13.69	*13.71*	K_0	13.61	14.32	14.91
	N_1	14.46	14.52	15.46	14.32	15.33	14.79	*14.81*	K_1	14.43	14.95	15.10
	N_2	14.67	15.35	15.43	15.22	15.01	15.22	*15.15*	K_2	14.89	14.21	14.61
	Mean	*14.31*	*14.49*	*14.87*	*14.28*	*14.83*	*14.57*	*14.56*				
25	N_0	8.07	8.48	8.49	9.12	8.00	7.92	*8.35*	K_0	9.20	10.29	10.61
	N_1	9.31	10.10	10.14	9.98	9.80	9.77	*9.85*	K_1	9.25	9.95	9.87
	N_2	10.64	11.17	11.59	11.00	11.26	11.14	*11.13*	K_2	9.57	9.52	9.74
	Mean	*9.34*	*9.92*	*10.07*	*10.03*	*9.69*	*9.61*	*9.78*				
26	N_0	10.61	9.68	10.12	9.23	10.56	10.63	*10.14*	K_0	11.33	10.75	12.13
	N_1	11.86	10.70	12.49	11.99	11.58	11.48	*11.68*	K_1	11.78	10.86	12.10
	N_2	11.95	12.75	13.60	12.99	12.60	12.71	*12.77*	K_2	11.31	11.51	11.99
	Mean	*11.47*	*11.04*	*12.07*	*11.40*	*11.58*	*11.61*	*11.53*				
27	N_0	10.30	11.33	11.24	11.23	11.06	10.59	*10.96*	K_0	11.08	11.80	12.55
	N_1	12.01	12.95	12.22	11.94	12.84	12.41	*12.40*	K_1	11.23	13.29	11.10
	N_2	11.89	12.88	13.22	12.26	11.72	14.02	*12.67*	K_2	11.90	12.08	13.04
	Mean	*11.40*	*12.39*	*12.23*	*11.81*	*11.87*	*12.34*	*12.01*				
28	N_0	10.09	9.78	9.47	9.08	10.55	9.71	*9.78*	K_0	10.10	9.77	9.44
	N_1	10.51	9.95	9.92	9.82	10.53	10.01	*10.13*	K_1	10.49	10.79	9.81
	N_2	10.45	10.60	9.65	10.41	10.01	10.28	*10.23*	K_2	10.46	9.76	9.78
	Mean	*10.35*	*10.11*	*9.68*	*9.77*	*10.36*	*10.00*	*10.05*				
29	N_0	11.14	11.31	11.34	11.19	11.20	11.40	*11.26*	K_0	10.96	11.70	11.11
	N_1	11.69	12.23	12.11	11.99	12.24	11.80	*12.01*	K_1	11.19	11.64	11.86
	N_2	10.78	10.70	11.19	10.59	11.25	10.83	*10.89*	K_2	11.47	10.90	11.67
	Mean	*11.21*	*11.41*	*11.55*	*11.26*	*11.56*	*11.35*	*11.39*				
30	N_0	11.42	13.10	11.15	12.00	10.63	13.04	*11.89*	K_0	10.65	11.48	11.77
	N_1	11.07	11.76	11.75	11.62	10.03	12.94	*11.53*	K_1	9.18	11.37	10.44
	N_2	10.38	12.06	11.60	10.28	10.33	13.44	*11.35*	K_2	13.05	14.07	12.30
	Mean	*10.96*	*12.31*	*11.50*	*11.30*	*10.33*	*13.14*	*11.59*				

Tops : tons per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
1	N_0	10.27	9.84	9.30	9.67	10.13	9.61	*9.80*	K_0	12.40	11.13	10.85
	N_1	13.99	12.69	11.51	11.94	12.89	13.35	*12.73*	K_1	13.55	12.46	11.19
	N_2	13.12	13.98	12.77	12.77	14.18	12.92	*13.29*	K_2	11.42	12.92	11.54
	Mean	*12.46*	*12.17*	*11.19*	*11.46*	*12.40*	*11.96*	*11.94*	±0.849. *Means : ±0.490*			
2	N_0	4.32	4.16	4.37	3.94	4.57	4.33	*4.28*	K_0	5.09	4.96	4.81
	N_1	5.23	5.34	5.39	5.67	4.80	5.49	*5.32*	K_1	4.86	4.94	4.83
	N_2	5.60	5.94	5.43	5.24	5.26	6.47	*5.66*	K_2	5.20	5.54	5.54
	Mean	*5.05*	*5.15*	*5.06*	*4.95*	*4.88*	*5.43*	*5.09*	±0.367. *Means : ±0.212*			
3	N_0	8.45	8.87	9.09	8.47	8.80	9.14	*8.80*	K_0	9.08	10.59	9.84
	N_1	9.79	9.47	9.84	9.80	9.10	10.21	*9.70*	K_1	9.03	10.23	10.62
	N_2	10.98	12.27	12.17	11.24	11.97	12.20	*11.80*	K_2	11.11	9.80	10.64
	Mean	*9.74*	*10.20*	*10.37*	*9.84*	*9.96*	*10.52*	*10.10*	±0.624. *Means : ±0.360*			
5	N_0	4.93	5.28	5.17	5.06	5.14	5.17	*5.12*	K_0	5.30	5.63	6.67
	N_1	4.61	5.49	6.53	5.87	4.98	5.79	*5.55*	K_1	5.25	5.25	5.94
	N_2	6.94	6.03	6.83	6.67	6.32	6.80	*6.60*	K_2	5.92	5.92	5.92
	Mean	*5.49*	*5.60*	*6.18*	*5.87*	*5.48*	*5.92*	*5.76*	±0.508. *Means : ±0.293*			
7	N_0	6.82	6.67	6.03	6.03	6.93	6.56	*6.51*	K_0	8.10	7.49	8.73
	N_1	8.45	8.04	7.88	8.43	7.97	7.97	*8.12*	K_1	8.67	7.55	8.34
	N_2	9.07	9.53	10.61	9.86	9.66	9.68	*9.73*	K_2	7.57	9.20	7.44
	Mean	*8.11*	*8.08*	*8.17*	*8.11*	*8.19*	*8.07*	*8.12*	±0.652. *Means : ±0.376*			
8	N_0	6.36	6.39	6.63	6.75	6.28	6.34	*6.46*	K_0	6.92	6.73	8.39
	N_1	6.99	6.47	7.57	6.35	6.34	8.33	*7.01*	K_1	6.71	6.85	7.21
	N_2	7.75	10.26	9.81	8.94	8.14	10.74	*9.27*	K_2	7.47	9.54	8.41
	Mean	*7.03*	*7.71*	*8.00*	*7.35*	*6.92*	*8.47*	*7.58*	±0.797. *Means : ±0.460*			
9	N_0	6.41	7.18	6.31	6.98	6.71	6.21	*6.63*	K_0	7.39	7.16	7.10
	N_1	7.24	6.58	7.90	6.95	7.08	7.70	*7.24*	K_1	7.35	6.75	7.67
	N_2	8.35	7.64	8.21	7.72	7.98	8.50	*8.07*	K_2	7.26	7.50	7.65
	Mean	*7.33*	*7.13*	*7.47*	*7.22*	*7.26*	*7.47*	*7.31*	±0.398. *Means : ±0.230*			
11	N_0	5.57	6.32	6.38	5.92	6.16	6.19	*6.09*	K_0	7.15	7.46	8.17
	N_1	6.84	7.97	7.79	7.61	7.41	7.58	*7.53*	K_1	6.88	7.16	8.71
	N_2	8.73	8.13	10.77	9.25	9.18	9.19	*9.21*	K_2	7.10	7.80	8.06
	Mean	*7.05*	*7.47*	*8.31*	*7.59*	*7.58*	*7.65*	*7.61*	±0.539. *Means : ±0.311*			
12	N_0	6.67	7.46	7.35	6.94	7.89	6.66	*7.16*	K_0	8.07	8.03	8.18
	N_1	8.24	7.41	8.46	7.20	8.85	8.05	*8.03*	K_1	8.63	7.40	9.75
	N_2	8.97	8.94	9.53	10.14	9.05	8.25	*9.15*	K_2	7.17	8.37	7.41
	Mean	*7.96*	*7.93*	*8.45*	*8.09*	*8.59*	*7.65*	*8.11*	±0.710. *Means : ±0.410*			
13	N_0	17.73	19.99	19.71	18.48	18.28	20.67	*19.14*	K_0	20.06	19.23	22.25
	N_1	20.67	21.08	19.64	21.01	21.08	19.30	*20.46*	K_1	18.28	21.63	22.25
	N_2	21.29	21.97	25.60	22.04	22.79	24.03	*22.95*	K_2	21.36	22.18	20.47
	Mean	*19.90*	*21.01*	*21.66*	*20.51*	*20.72*	*21.34*	*20.86*	±1.43. *Means : ±0.826*			

Tops: tons per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
14	N_0	5.41	8.81	11.21	7.58	9.39	8.46	*8.48*	K_0	6.03	10.95	13.08
	N_1	5.82	12.26	12.00	11.38	8.11	10.59	*10.03*	K_1	5.97	10.71	9.01
	N_2	7.67	13.05	11.41	11.09	8.19	12.85	*10.71*	K_2	6.90	12.47	12.52
	Mean	*6.30*	*11.38*	*11.54*	*10.02*	*8.56*	*10.63*	*9.74*	±1.46.	*Means :*	±*0.843*	
15	N_0	6.32	5.81	6.08	5.54	6.16	6.51	*6.07*	K_0	7.88	7.13	6.88
	N_1	6.99	7.29	7.70	8.21	7.36	6.40	*7.33*	K_1	7.65	6.96	7.58
	N_2	8.97	8.81	8.05	8.13	8.67	9.02	*8.61*	K_2	6.75	7.82	7.36
	Mean	*7.43*	*7.30*	*7.28*	*7.30*	*7.40*	*7.31*	*7.34*	±0.641.	*Means :*	±*0.370*	
16	N_0	7.13	7.29	6.44	6.81	7.08	6.96	*6.95*	K_0	7.92	8.31	8.98
	N_1	7.92	9.33	8.92	8.50	9.29	8.38	*8.72*	K_1	8.58	8.98	8.38
	N_2	9.63	9.00	9.98	9.90	9.56	9.15	*9.54*	K_2	8.17	8.33	7.98
	Mean	*8.22*	*8.54*	*8.45*	*8.40*	*8.64*	*8.16*	*8.40*	±0.419.	*Means :*	±*0.242*	
17	N_0	5.10	4.88	5.63	4.73	5.18	5.70	*5.20*	K_0	5.96	6.38	6.03
	N_1	5.81	7.18	7.10	6.40	6.97	6.72	*6.70*	K_1	5.87	6.65	7.13
	N_2	7.16	7.81	7.44	7.24	7.50	7.66	*7.47*	K_2	6.23	6.85	7.01
	Mean	*6.02*	*6.63*	*6.72*	*6.12*	*6.55*	*6.70*	*6.46*	±0.373.	*Means :*	±*0.215*	
18	N_0	5.74	5.67	6.02	5.82	5.57	6.04	*5.81*	K_0	6.71	8.12	7.26
	N_1	6.88	7.28	7.41	7.42	7.02	7.13	*7.19*	K_1	7.02	6.88	7.04
	N_2	8.13	7.98	8.09	8.85	8.35	7.00	*8.07*	K_2	7.02	5.93	7.22
	Mean	*6.92*	*6.98*	*7.17*	*7.36*	*6.98*	*6.72*	*7.02*	±0.501.	*Means :*	±*0.289*	
20	N_0	8.61	10.42	10.73	9.36	9.05	11.36	*9.92*	K_0	11.67	11.34	11.24
	N_1	11.92	12.90	13.47	11.87	12.22	14.21	*12.77*	K_1	10.21	11.35	12.70
	N_2	13.92	13.26	13.73	13.03	12.99	14.90	*13.64*	K_2	12.57	13.90	14.00
	Mean	*11.48*	*12.20*	*12.65*	*11.42*	*11.42*	*13.49*	*12.11*	±0.566.	*Means :*	±*0.327*	
21	N_0	7.17	7.04	6.65	6.05	7.61	7.19	*6.95*	K_0	9.27	8.42	7.82
	N_1	9.10	8.94	9.36	9.14	9.15	9.10	*9.13*	K_1	10.00	8.63	8.85
	N_2	11.04	10.57	10.82	10.33	10.73	11.38	*10.81*	K_2	8.02	9.49	10.15
	Mean	*9.10*	*8.85*	*8.94*	*8.50*	*9.16*	*9.22*	*8.96*	±0.491.	*Means :*	±*0.283*	
22	N_0	9.75	8.54	8.78	8.86	8.69	9.52	*9.02*	K_0	9.55	9.98	10.64
	N_1	9.55	11.16	10.73	9.78	11.88	9.78	*10.48*	K_1	10.64	10.70	10.56
	N_2	11.22	11.36	12.29	11.54	11.34	12.00	*11.63*	K_2	10.33	10.38	10.59
	Mean	*10.17*	*10.35*	*10.60*	*10.06*	*10.64*	*10.43*	*10.38*	±0.751.	*Means :*	±*0.434*	
23	N_0	5.14	5.19	4.17	4.46	4.90	5.14	*4.83*	K_0	7.79	7.97	7.06
	N_1	6.66	8.12	8.21	7.28	7.94	7.77	*7.66*	K_1	6.99	8.21	7.75
	N_2	11.58	10.96	10.48	11.08	10.12	11.81	*11.00*	K_2	8.59	8.08	8.04
	Mean	*7.79*	*8.09*	*7.62*	*7.61*	*7.65*	*8.24*	*7.83*	±0.612.	*Means :*	±*0.353*	
24	N_0	6.77	7.90	6.41	6.51	7.41	7.16	*7.03*	K_0	7.70	7.73	7.32
	N_1	8.03	7.45	8.32	7.64	7.96	8.19	*7.93*	K_1	7.86	8.32	8.25
	N_2	8.70	8.93	8.93	8.61	9.06	8.90	*8.86*	K_2	7.93	8.22	8.09
	Mean	*7.83*	*8.09*	*7.89*	*7.59*	*8.14*	*8.08*	*7.94*	±0.457.	*Means :*	±*0.264*	

Tops: tons per acre

Centre		P_0	P_1	P_2	K_0	K_1	K_2	*Mean*		P_0	P_1	P_2
25	N_0	2.89	2.50	3.37	3.18	2.87	2.71	*2.92*	K_0	4.08	3.60	4.50
	N_1	4.26	4.21	3.81	4.08	4.07	4.13	*4.09*	K_1	3.76	4.18	4.05
	N_2	5.15	5.39	4.97	4.92	5.05	5.55	*5.17*	K_2	4.47	4.31	3.60
	Mean	*4.10*	*4.03*	*4.05*	*4.06*	*4.00*	*4.13*	*4.06*	±0.325. *Means* : ±*0.188*			
26	N_0	6.76	6.31	6.15	6.31	5.86	7.04	*6.40*	K_0	8.91	9.15	7.97
	N_1	7.75	7.47	7.62	6.89	7.36	8.60	*7.62*	K_1	7.97	8.54	9.33
	N_2	11.04	13.83	11.78	12.83	12.62	11.20	*12.22*	K_2	8.67	9.91	8.25
	Mean	*8.52*	*9.20*	*8.52*	*8.68*	*8.61*	*8.95*	*8.75*	±0.872. *Means* : ±*0.503*			
27	N_0	8.24	8.41	9.23	8.91	8.58	8.39	*8.63*	K_0	9.91	11.92	11.79
	N_1	11.05	11.87	11.46	11.16	11.48	11.74	*11.46*	K_1	11.05	11.35	10.49
	N_2	13.08	13.78	13.99	13.56	12.84	14.45	*13.62*	K_2	11.40	10.79	12.39
	Mean	*10.79*	*11.35*	*11.56*	*11.21*	*10.96*	*11.53*	*11.23*	±0.612. *Means* : ±*0.353*			
29	N_0	23.24	22.48	22.19	23.50	21.22	23.19	*22.64*	K_0	22.88	24.40	24.97
	N_1	23.74	23.60	23.81	23.34	22.82	24.99	*23.72*	K_1	23.57	22.83	22.70
	N_2	24.87	25.55	27.13	25.41	25.05	27.08	*25.85*	K_2	25.40	24.40	25.47
	Mean	*23.95*	*23.88*	*24.38*	*24.08*	*23.03*	*25.09*	*24.07*	±0.987. *Means* : ±*0.570*			

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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)			St. error	Curvature (excess of extra response to second dressing over response to first dressing)			St. error
		N	P	K		N	P	K	
TOTAL SUGAR : cwt. per acre									
COARSE SANDS									
1 Allscott I ..	*51.4*	+4.6*	+2.1	+0.2	±1.74	−3.4	−1.1	+2.2	±3.03
2 Bardney II ..	*36.9*	+5.9**	+4.2*	+2.4	±1.72	−6.3	−0.6	−1.8	±2.97
3 Brigg II	*46.4*	+9.1**	+1.0	+0.3	±2.24	−2.3	+0.8	+3.5	±3.87
4 Bury I	*34.1*	+8.4**	+3.7	+8.7**	±1.88	−10.0**	−4.9	−5.7	±3.25
5 Cantley I.. ..	*34.4*	+4.4*	−0.7	+3.2	±1.99	−2.4	−1.3	−5.8	±3.45
6 Tunstall	*25.8*	+7.5**	−0.5	+6.8**	±1.05	−5.1*	+2.3	−3.4	±1.81
7 Wissington II ..	*45.5*	+10.1**	+0.9	+6.6**	±1.73	−6.3	−0.9	+2.4	±3.00
Mean	*39.2*	*+7.1*	*+1.5*	*+4.0*		*−5.1*	*−0.8*	*−1.2*	
FINE SANDS									
8 Brigg I	*49.9*	+7.1**	+1.4	+1.1	±1.07	−3.7	+0.6	−0.3	±1.85
9 Bury II	*37.1*	+4.5*	+0.7	+0.4	±1.71	−0.9	+2.7	+0.6	±2.96
10 Ipswich	*34.8*	+0.9	−1.4	+6.2**	±1.51	+1.1	+1.4	−3.4	±2.62
11 Kidderminster I	*37.6*	+5.1*	+5.0*	+7.9**	±2.31	−5.3	−2.0	+2.5	±3.99
12 King's Lynn II..	*44.6*	+8.8**	+1.9	+2.2	±1.88	−2.0	+1.1	+2.0	±3.25
13 Spalding	*58.3*	−0.5	+0.6	+2.6	±1.63	+0.7	−4.2	−1.2	±2.83
Mean	*43.7*	*+4.3*	*+1.4*	*+3.4*		*−1.7*	*−0.1*	*0.0*	
LIGHT LOAMS									
14 Allscott II ..	*21.4*	+2.3	+16.4**	+8.3*	±3.21	−0.1	−13.8*	+4.5	±5.56
15 Bardney I ..	*49.6*	+6.8**	−1.3	+1.4	±2.18	+0.2	−1.5	+2.0	±3.78
16 Cantley II ..	*43.3*	+3.5*	−1.5	+3.1	±1.50	+1.5	+2.1	+1.3	±2.60
17 King's Lynn I ..	*38.3*	+9.8**	+4.0	+1.0	±2.06	+0.4	−3.8	−1.4	±3.56
18 Newark I ..	*49.7*	+8.3**	+1.0	+2.5	±1.46	+0.5	+0.2	+0.7	±2.52
19 Peterboro' I ..	*29.1*	—0.7	+5.2**	+1.0	±1.70	+2.3	−6.4*	−4.6	±2.94
20 Poppleton I ..	*38.3*	+1.5	+2.0	+4.2	±2.72	−6.3	−0.6	−1.6	±4.71
21 Poppleton II ..	*40.3*	+6.5**	+1.2	−0.6	±1.42	−1.3	+0.2	−0.4	±2.46
22 Selby I	*32.7*	+3.1	+2.4	+1.9	±1.86	+2.7	+2.4	−2.7	±3.22
23 Wissington III..	*47.6*	+12.7**	−0.2	+0.8	±1.49	−3.7	−2.2	−2.8	±2.57
Mean	*39.0*	*+5.4*	*+2.9*	*+2.4*		*−0.4*	*−2.3*	*−0.5*	
HEAVY LOAM									
24 Colwick	*51.9*	+4.5**	+2.3	+0.7	±1.27	−2.3	+1.3	−2.9	±2.19
CLAY LOAMS									
25 Felstead I ..	*38.1*	+10.6**	+2.8*	−1.0	±1.07	−1.2	−1.6	0.0	±1.85
26 Felstead II ..	*41.5*	+9.2**	+1.4	+1.3	±1.80	−3.0	+6.6	−0.3	±3.12
27 Rothamsted I ..	*38.8*	+4.7	+2.2	+2.5	±2.40	−4.3	−4.8	+2.1	±4.16
28 Selby II	*36.8*	+1.8	−2.4	+1.7	±1.24	−2.6	0.0	−2.3	±2.15
Mean	*38.8*	*+6.6*	*+1.0*	*+1.1*		*−2.8*	*0.0*	*−0.1*	
FENS									
29 Ely..	*38.0*	−3.1	+0.9	+0.6	±1.55	−8.1**	+0.3	−3.2	±2.67
30 Peterboro' II ..	*36.4*	−2.2	+1.0	+5.8*	±2.17	+0.4	−7.4	+13.6**	±3.76
Mean	*37.2*	*−2.6*	*+1.0*	*+3.2*		*−3.8*	*−3.6*	*+5.2*	
Mean	*40.3*	*+5.2*	*+1.9*	*+2.8*		*−2.4*	*−1.2*	*−0.2*	

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
	ROOTS (washed) : tons per acre						
COARSE SANDS							
1 Allscott I	*15.88*	+1.64	+0.52	+0.16	−1.12	−0.16	+0.42
2 Bardney II	*10.59*	+2.04	+0.96	+0.38	−1.60	−0.40	−0.46
3 Brigg II	*13.77*	+2.89	+0.16	−0.08	−0.51	0.00	+1.20
4 Bury I	*10.30*	+2.90	+1.10	+2.50	−2.42	−1.34	−1.58
5 Cantley I	*10.21*	+1.59	−0.18	+0.55	−0.73	−0.20	−1.51
6 Tunstall	*7.50*	+2.52	−0.09	+1.49	−1.16	+0.61	−0.65
7 Wissington II	*13.00*	+3.27	+0.26	+1.48	−1.61	−0.12	+0.52
Mean	*11.61*	*+2.41*	*+0.39*	*+0.93*	*−1.31*	*−0.23*	*−0.29*
FINE SANDS							
8 Brigg I	*14.41*	+2.40	+0.56	−0.02	−0.64	+0.40	+0.20
9 Bury II	*10.36*	+1.28	+0.39	−0.17	−0.24	+0.81	+0.33
10 Ipswich	*10.66*	+0.85	−0.28	+1.92	+0.33	+0.50	−1.02
11 Kidderminster I ..	*11.17*	+1.96	+1.46	+1.94	−1.50	−0.72	+0.60
12 King's Lynn II	*12.45*	+2.53	+0.44	+0.62	−0.31	+0.56	+0.56
13 Spalding	*17.48*	+0.39	+0.42	+0.26	+0.75	−1.26	−0.54
Mean	*12.76*	*+1.57*	*+0.50*	*+0.76*	*−0.27*	*+0.05*	*+0.02*
LIGHT LOAMS							
14 Allscott II	*6.51*	+0.81	+4.75	+2.25	+0.03	−4.05	+1.23
15 Bardney I	*13.84*	+2.18	−0.33	+0.27	+0.08	−0.35	+0.53
16 Cantley II	*12.56*	+1.43	−0.41	+0.98	+0.69	+0.57	+0.54
17 King's Lynn I	*10.70*	+2.61	+1.05	+0.35	+0.21	−0.93	−0.45
18 Newark I	*13.67*	+2.36	+0.35	+0.52	+0.04	−0.41	+0.04
19 Peterboro' I	*7.13*	−0.38	+1.43	+0.34	+0.64	−1.49	−1.22
20 Poppleton I	*11.56*	+0.55	+0.49	+1.11	−1.89	−0.55	−0.31
21 Poppleton II	*11.72*	+2.19	+0.28	−0.10	−0.29	−0.20	−0.42
22 Selby I	*9.63*	+0.92	+0.43	+0.26	+0.70	+0.05	−1.06
23 Wissington III	*13.28*	+3.92	−0.08	+0.07	−0.96	−0.68	−0.57
Mean	*11.06*	*+1.66*	*+0.80*	*+0.60*	*−0.08*	*−0.80*	*−0.17*
HEAVY LOAM							
24 Colwick	*14.56*	+1.44	+0.56	+0.29	−0.76	+0.20	−0.81
CLAY LOAMS							
25 Felstead I	*9.78*	+2.78	+0.73	−0.42	−0.22	−0.43	+0.26
26 Felstead II	*11.53*	+2.63	+0.60	+0.21	−0.45	+1.46	−0.15
27 Rothamsted I	*12.01*	+1.71	+0.83	+0.53	−1.17	−1.15	+0.41
28 Selby II	*10.05*	+0.45	−0.67	+0.23	−0.25	−0.19	−0.95
Mean	*10.84*	*+1.89*	*+0.37*	*+0.14*	*−0.52*	*−0.08*	*−0.11*
FENS							
29 Ely	*11.39*	−0.37	+0.34	+0.09	−1.87	−0.06	−0.51
30 Peterboro' II	*11.59*	−0.54	+0.54	+1.84	+0.18	−2.16	+3.78
Mean	*11.49*	*−0.46*	*+0.44*	*+0.96*	*−0.84*	*−1.11*	*+1.64*
Mean	*11.64*	*+1.70*	*+0.55*	*+0.66*	*−0.54*	*−0.39*	*−0.05*

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Station	*Mean yield*	Linear Response (response to the double dressing)			St. error	Curvature (excess of extra response to second dressing over response to first dressing)			St. error
		N	P	K		N	P	K	
		TOPS : tons per acre							
COARSE SANDS									
1 Allscott I ..	*11.94*	+3.49**	−1.27	+0.50	±0.693	−2.37	−0.69	−1.38	±1.20
2 Bardney II ..	*5.09*	+1.38**	+0.01	+0.48	±0.299	−0.70	−0.19	+0.62	±0.519
3 Brigg II	*10.10*	+3.00**	+0.63	+0.68	±0.509	+1.20	−0.29	+0.44	±0.882
5 Cantley I ..	*5.76*	+1.48**	+0.69	+0.05	±0.415	+0.62	+0.47	+0.83	±0.718
7 Wissington II ..	*8.12*	+3.22**	+0.06	−0.04	±0.533	0.00	+0.12	−0.20	±0.922
Mean	*8.20*	*+2.51*	*+0.02*	*+0.33*		*−0.25*	*−0.12*	*+0.06*	
FINE SANDS									
8 Brigg I	*7.58*	+2.81**	+0.97	+1.12	±0.651	+1.71	−0.39	+1.98	±1.13
9 Bury II ..	*7.31*	+1.44**	+0.14	+0.25	±0.325	+0.22	+0.54	+0.17	±0.563
11 Kidderminster I	*7.61*	+3.12**	+1.26*	+0.06	±0.440	+0.24	+0.42	+0.08	±0.762
12 King's Lynn II..	*8.11*	+1.99**	+0.49	−0.44	±0.580	+0.25	+0.55	−1.44	±1.00
13 Spalding ..	*20.86*	+3.81**	+1.76	+0.83	±1.17	+1.17	−0.46	+0.41	±2.02
Mean	*10.29*	*+2.63*	*+0.92*	*+0.36*		*+0.72*	*+0.13*	*+0.24*	
LIGHT LOAMS									
14 Allscott II ..	*9.74*	+2.23	+5.24**	+0.61	±1.19	−0.87	−4.92*	+3.53	±2.06
15 Bardney I ..	*7.34*	+2.54**	−0.15	+0.01	±0.523	+0.02	+0.11	−0.19	±0.906
16 Cantley II ..	*8.40*	+2.59**	+0.23	−0.24	±0.342	−0.95	−0.41	−0.72	±0.592
17 King's Lynn I ..	*6.46*	+2.27**	+0.70*	+0.58	±0.305	−0.73	−0.52	−0.28	±0.527
18 Newark I ..	*7.02*	+2.26**	+0.25	−0.64	±0.409	−0.50	+0.13	+0.12	±0.708
20 Poppleton I ..	*12.11*	+3.72**	+1.17*	+2.07**	±0.462	−1.98*	−0.27	+2.07*	±0.800
21 Poppleton II ..	*8.96*	+3.86**	−0.16	+0.72	±0.401	−0.50	+0.34	−0.60	±0.694
22 Selby I	*10.38*	+2.61**	+0.43	+0.37	±0.613	−0.31	+0.07	−0.79	±1.06
23 Wissington III	*7.83*	+6.17**	−0.17	+0.63	±0.500	+0.51	−0.77	+0.55	±0.865
Mean	*8.69*	*+3.14*	*+0.84*	*+0.46*		*−0.59*	*−0.69*	*+0.41*	
HEAVY LOAM									
24 Colwick ..	*7.94*	+1.83**	+0.06	+0.49	±0.373	+0.03	−0.46	−0.61	±0.646
CLAY LOAMS ..									
25 Felstead I ..	*4.06*	+2.25**	−0.05	+0.07	±0.265	−0.09	+0.09	+0.19	±0.460
26 Felstead II ..	*8.75*	+5.82**	0.00	+0.27	±0.712	+3.38*	−1.36	+0.41	±1.23
27 Rothamsted I ..	*11.23*	+4.99**	+0.77	+0.32	±0.500	−0.67	−0.35	+0.82	±0.865
Mean	*8.01*	*+4.35*	*+0.24*	*+0.22*		*+0.87*	*−0.54*	*+0.47*	
FENS									
29 Ely	*24.07*	+3.21**	+0.43	+1.01	±0.806	+1.05	+0.57	+3.11*	±1.40
Mean	*9.45*	*+3.00*	*+0.56*	*+0.41*		*+0.03*	*−0.32*	*+0.38*	

Station	Mean	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
		SUGAR PERCENTAGE					
COARSE SANDS							
1 Allscott I	*16.21*	−0.24	+0.15	−0.10	+0.10	−0.19	+0.28
2 Bardney II	*17.44*	−0.52	+0.33	+0.47	−0.28	+0.27	−0.03
3 Brigg II	*16.88*	−0.25	+0.17	+0.20	−0.21	+0.29	−0.18
4 Bury I	*16.52*	−0.52	+0.04	+0.30	−0.78	−0.26	−0.30
5 Cantley I..	*16.82*	−0.50	+0.02	+0.70	+0.08	−0.36	−0.40
6 Tunstall	*17.17*	−0.77	−0.04	+1.10	−0.55	+0.14	−0.88
7 Wissington II	*17.52*	−0.51	−0.06	+0.55	−0.25	−0.22	+0.11
Mean	*16.94*	*−0.47*	*+0.09*	*+0.46*	*−0.27*	*−0.05*	*−0.20*
FINE SANDS							
8 Brigg I	*17.32*	−0.40	−0.17	+0.42	−0.50	−0.33	−0.36
9 Bury II	*17.90*	−0.03	−0.36	+0.51	−0.05	−0.02	−0.23
10 Ipswich	*16.31*	−0.89	−0.22	−0.02	+0.11	−0.22	−0.02
11 Kidderminster I.. ..	*16.84*	−0.69	+0.05	+0.58	−0.07	+0.19	+0.10
12 King's Lynn II	*17.90*	+0.01	+0.14	−0.02	−0.39	−0.42	+0.12
13 Spalding	*16.69*	−0.54	−0.23	+0.49	−0.46	−0.03	+0.21
Mean	*17.16*	*−0.42*	*−0.13*	*+0.33*	*−0.23*	*−0.14*	*−0.03*
LIGHT LOAMS							
14 Allscott II	*16.19*	−0.31	+0.84	+0.68	−0.03	−0.72	+0.28
15 Bardney I	*17.93*	−0.35	−0.05	+0.13	+0.05	−0.13	+0.05
16 Cantley II	*17.24*	−0.59	0.00	−0.06	−0.33	+0.06	−0.22
17 King's Lynn I	*17.89*	+0.21	+0.12	−0.14	−0.15	−0.20	+0.12
18 Newark I	*18.16*	−0.09	−0.09	+0.18	+0.11	+0.63	+0.24
19 Peterboro' I	*20.39*	+0.60	−0.36	−0.20	−0.24	−0.22	+0.08
20 Poppleton I	*16.54*	−0.12	+0.09	+0.19	+0.10	+0.47	−0.31
21 Poppleton II	*17.18*	−0.42	+0.09	−0.11	−0.06	+0.53	+0.39
22 Selby I	*16.96*	−0.12	+0.44	+0.47	+0.12	+1.08	+0.51
23 Wissington III	*17.93*	−0.50	−0.02	+0.19	0.00	+0.16	−0.29
Mean	*17.64*	*−0.17*	*+0.11*	*+0.13*	*−0.04*	*+0.17*	*+0.08*
HEAVY LOAM							
24 Colwick	*17.84*	−0.24	+0.11	−0.12	+0.18	+0.17	−0.06
CLAY LOAMS							
25 Felstead I	*19.51*	−0.14	−0.03	+0.30	−0.24	+0.03	−0.50
26 Felstead II	*18.00*	−0.02	−0.30	+0.31	−0.54	+0.56	+0.15
27 Rothamsted I	*16.13*	−0.37	−0.17	+0.39	−0.27	−0.55	+0.33
28 Selby II	*18.32*	+0.04	−0.02	+0.42	−0.90	+0.24	+0.42
Mean	*17.99*	*−0.12*	*−0.13*	*+0.36*	*−0.49*	*+0.07*	*+0.10*
FENS							
29 Ely	*16.62*	−0.84	−0.12	+0.18	−0.76	+0.18	−0.70
30 Peterboro' II	*15.69*	−0.27	−0.32	+0.01	−0.17	−0.04	+0.61
Mean	*16.16*	*−0.56*	*−0.22*	*+0.10*	*−0.46*	*+0.07*	*−0.04*
Mean	*17.33*	*−0.31*	*0.00*	*+0.27*	*−0.21*	*+0.04*	*−0.02*

Station	Mean	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
PLANT NUMBER : thousands per acre							
COARSE SANDS							
1 Allscott I	*23.0*	+1.1	+1.0	+1.1	−3.1	+0.8	+0.5
2 Bardney II	*30.3*	+1.3	+0.7	−0.1	−2.3	−1.1	−1.7
3 Brigg II	*22.3*	+0.9	+0.1	+0.3	−0.3	+0.9	−0.5
4 Bury I	*27.8*	+3.3	−0.2	+4.1	−5.9	−3.2	−3.5
5 Cantley I	*33.8*	+1.2	−0.5	+0.8	−0.6	+1.1	+2.2
6 Tunstall	*56.7*	+2.1	+1.2	+7.0	−12.5	−4.8	−4.8
7 Wissington II	*26.1*	+1.1	−1.3	+1.7	−1.1	+2.1	−0.9
Mean	*31.4*	*+1.6*	*+0.1*	*+2.1*	*−3.7*	*−0.6*	*−1.2*
FINE SANDS							
8 Brigg I	*24.0*	−1.5	+2.7	−0.2	+3.1	+2.5	+2.2
9 Bury II	*22.8*	0.0	+1.3	+0.9	+1.2	+0.9	−3.3
10 Ipswich	*30.4*	−1.0	+0.4	−0.1	+2.2	+0.4	−2.3
11 Kidderminster I	*25.7*	−1.6	−0.2	+0.6	+1.2	+0.2	−2.8
12 King's Lynn II	*27.8*	−0.2	−0.3	−0.3	+0.2	+0.5	−0.9
13 Spalding	*38.4*	−0.5	−0.9	−1.4	+0.7	+0.1	+3.4
Mean	*28.2*	*−0.8*	*+0.5*	*−0.1*	*+1.4*	*+0.8*	*−0.6*
LIGHT LOAMS							
14 Allscott II	*18.8*	+0.6	+9.1	+0.1	+1.2	−10.5	+2.7
15 Bardney I	*30.5*	+0.3	−2.5	+1.1	+1.7	+1.7	+2.1
16 Cantley II	*21.6*	−0.3	−0.9	−0.9	−0.3	+0.7	+0.7
17 King's Lynn I	*27.4*	+1.2	+1.0	+2.2	0.0	+0.6	+0.6
18 Newark I	*31.0*	+1.1	−1.2	+0.5	+3.3	+1.2	+0.3
19 Peterboro' I	*22.9*	−1.0	+0.5	−0.7	+1.2	−2.9	−1.9
20 Poppleton I	*26.5*	−0.3	+1.1	−0.2	−1.5	−4.3	−3.0
21 Poppleton II	*24.1*	−0.2	−0.7	+0.1	−0.4	−0.3	+0.1
22 Selby I	*26.6*	+0.2	+0.8	+1.2	−0.6	−0.4	+1.0
23 Wissington III	*31.0*	−0.5	+0.3	+0.3	−0.1	−0.1	−0.1
Mean	*26.0*	+0.1	+0.8	+0.4	+0.4	−1.4	+0.2
HEAVY LOAM							
24 Colwick	*32.8*	−0.6	−1.6	−1.0	−1.0	−0.4	+1.4
CLAY LOAMS							
25 Felstead I	*23.8*	+1.2	0.0	+1.4	−0.6	0.0	+1.8
26 Felstead II	*25.7*	−1.8	−0.9	−0.1	+1.2	−0.9	−0.3
27 Rothamsted I	*31.3*	+0.9	+0.9	+0.2	+2.5	−1.7	+2.8
28 Selby II	*27.2*	+0.2	−2.8	−1.3	+0.6	−2.4	−4.3
Mean	*27.0*	*+0.1*	*−0.7*	*0.0*	*+0.9*	*−1.2*	*0.0*
FENS							
29 Ely	*33.6*	+0.1	+0.8	−0.5	+0.9	+0.2	+0.3
30 Peterboro' II	*24.7*	+0.8	+2.4	+3.4	−1.2	−1.2	+3.0
Mean	*29.2*	*+0.4*	*+1.6*	*+1.4*	*−0.2*	*−0.5*	*+1.6*
Mean	*28.3*	*+0.3*	*+0.3*	*+0.7*	*−0.3*	*−0.7*	*−0.2*

Station	*Mean*	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
		PERCENTAGE PURITY					
COARSE SANDS							
2 Bardney II	*87.7*	+0.4	+0.9	+1.6	+2.2	−2.9	0.0
4 Bury I	*91.2*	+0.5	0.0	0.0	−0.3	−0.8	+0.6
5 Cantley I..	*91.0*	−0.8	−0.2	−0.3	−0.6	+0.6	−2.9
7 Wissington II	*90.9*	−0.4	+0.1	+0.1	0.0	+0.3	+0.5
Mean	*90.2*	*−0.1*	*+0.2*	*+0.4*	*+0.3*	*−0.7*	*−0.4*
FINE SANDS							
9 Bury II	*88.9*	+0.4	−0.8	+0.6	+0.8	−1.0	+0.2
11 Kidderminster I.. ..	*89.6*	−0.6	+0.3	+0.6	−1.0	+0.3	+0.6
12 King's Lynn II	*91.3*	−0.4	−0.1	+0.1	+0.6	+0.1	+0.1
13 Spalding	*87.4*	−0.8	−0.4	+1.2	−0.4	+1.4	+1.0
Mean	*89.3*	*−0.4*	*−0.2*	*+0.6*	*0.0*	*+0.2*	*+0.5*
LIGHT LOAMS							
15 Bardney I	*86.8*	−1.0	−0.6	+0.1	+3.0	0.0	+1.5
16 Cantley II	*90.5*	+0.1	+1.9	−0.8	+0.7	−0.1	+0.4
17 King's Lynn I	*90.8*	0.0	0.0	−0.1	−0.2	−0.2	+0.3
18 Newark I	*89.9*	+0.5	−0.1	0.0	+0.1	−0.3	+1.0
20 Poppleton I	*89.3*	−0.2	−0.4	+1.9	0.0	+0.8	+0.5
21 Poppleton II	*90.0*	+0.1	−0.1	0.0	−0.5	+1.1	+1.6
22 Selby I	*86.1*	+0.9	+1.0	+0.6	+0.7	+0.4	0.0
23 Wissington III	*90.2*	−0.9	+0.3	+0.1	+0.1	+0.7	−0.5
Mean	*89.2*	*−0.1*	*+0.2*	*+0.2*	*+0.5*	*+0.3*	*+0.6*
HEAVY LOAM							
24 Colwick	*89.4*	0.0	−0.4	+0.3	+1.2	0.0	+1.5
CLAY LOAMS							
25 Felstead I	*87.7*	+0.1	+0.4	−0.1	−0.3	+0.2	+0.5
26 Felstead II	*88.2*	+0.1	0.0	0.0	−0.5	+1.0	−0.2
28 Selby II	*86.4*	+1.9	+0.6	+1.6	−1.1	0.0	+1.6
Mean	*87.4*	*+0.7*	*+0.3*	*+0.5*	*−0.6*	*+0.4*	*+0.6*
FENS							
29 Ely	*92.0*	−0.2	+0.1	+0.3	+0.6	+0.3	+0.9
Mean	*89.3*	*0.0*	*+0.1*	*+0.4*	*+0.2*	*+0.1*	*+0.4*

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
	TOTAL SUGAR: cwt. per acre				ROOTS (washed): tons per acre		
COARSE SANDS							
1 Allscott I	+2.8	+0.9	+1.5	±2.14	+0.94	+0.32	+0.50
2 Bardney II	+1.2	+3.6	+1.5	±2.10	+0.18	+1.05	+0.54
3 Brigg II..	+3.4	−3.5	−4.4	±2.74	+1.04	−1.10	−1.06
4 Bury I	+3.0	+2.4	−2.0	±2.30	+1.00	+0.80	−0.63
5 Cantley I	−2.2	+1.2	−4.4	±2.44	−0.47	+0.32	−1.32
6 Tunstall	−3.5*	+1.0	−0.2	±1.28	−0.98	+0.18	+0.04
7 Wissington II	+1.0	−0.8	+1.7	±2.12	+0.36	−0.29	+0.32
Mean	*+0.8*	*+0.7*	*−0.9*		*+0.30*	*+0.18*	*−0.23*
FINE SANDS							
8 Brigg I	+0.8	+1.1	+0.2	±1.31	+0.39	+0.33	−0.06
9 Bury II	+0.7	+4.5*	+2.8	±2.09	+0.14	+0.98	+0.80
10 Ipswich	+2.7	−3.0	−2.8	±1.85	+0.96	−0.68	−0.66
11 Kidderminster I ..	−0.7	−1.8	−1.9	±2.82	0.00	−0.40	−0.60
12 King's Lynn II.. ..	+0.2	+0.2	+1.4	±2.30	−0.06	−0.09	+0.22
13 Spalding	+2.2	−0.9	−3.4	±2.00	+0.42	−0.28	−0.59
Mean	*+1.0*	*0.0*	*−0.6*		*+0.31*	*−0.02*	*−0.15*
LIGHT LOAMS							
14 Allscott II	−3.8	+4.7	+3.0	±3.93	−1.20	+1.38	+0.85
15 Bardney I	+0.5	+0.2	+3.8	±2.67	−0.04	+0.04	+0.96
16 Cantley II	−4.6*	+2.9	−2.2	±1.84	−0.88	+0.90	−0.36
17 King's Lynn I	+0.4	−1.0	−0.2	±2.52	+0.13	−0.32	+0.02
18 Newark I	−2.7	−1.3	−3.1	±1.78	−0.68	−0.56	−0.90
19 Peterboro' I	−1.0	+4.2	+2.4	±2.08	−0.32	+0.98	+0.64
20 Poppleton I	−2.1	+4.5	+3.9	±3.33	−0.48	+1.20	+1.22
21 Poppleton II	+2.7	+0.8	+3.1	±1.74	+0.64	0.00	+1.16
22 Selby I	+1.4	+0.8	+1.2	±2.28	+0.02	−0.04	−0.28
23 Wissington III ..	+0.2	0.0	+2.8	±1.82	−0.14	−0.06	+0.86
Mean	*−0.9*	*+1.6*	*+1.5*		*−0.30*	*+0.35*	*+0.42*
HEAVY LOAM							
24 Colwick	+1.6	−0.5	−2.5	±1.55	+0.41	−0.19	−0.79
CLAY LOAMS							
25 Felstead I	+1.4	+2.9*	−2.6	±1.31	+0.26	+0.67	−0.62
26 Felstead II	+3.2	−2.7	−1.3	±2.21	+1.07	−0.84	−0.06
27 Rothamsted I	+0.4	+4.2	−1.0	±2.94	+0.20	+1.20	−0.16
28 Selby II..	−1.0	−1.7	−0.1	±1.52	−0.09	−0.38	−0.01
Mean	*+1.0*	*+0.7*	*−1.2*		*+0.36*	*+0.16*	*−0.21*
FENS							
29 Ely	+0.6	−0.4	+0.8	±1.89	+0.10	+0.02	+0.02
30 Peterboro' II	+3.5	+3.9	−2.4	±2.66	+0.74	+1.06	−0.94
Mean	*+2.0*	*+1.8*	*−0.8*		*+0.42*	*+0.54*	*−0.46*
Mean	*+0.4*	*+0.9*	*−0.1*		*+0.12*	*+0.21*	*−0.03*

N

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
	TOPS : tons per acre				SUGAR PERCENTAGE		
COARSE SANDS							
1 Allscott I	+0.31	+0.10	+0.84	±0.849	−0.08	−0.05	−0.04
2 Bardney II	−0.11	+0.42	+0.31	±0.367	+0.27	0.00	−0.22
3 Brigg II..	+0.28	+0.14	−0.62	±0.624	−0.05	+0.09	−0.28
4 Bury I	—	—	—	—	−0.14	+0.04	0.00
5 Cantley I	−0.18	+0.01	−0.68	±0.508	−0.33	+0.04	−0.01
6 Tunstall	—	—	—	—	−0.12	+0.17	−0.19
7 Wissington II	+1.16	−0.36	−0.38	±0.652	−0.13	+0.04	+0.16
Mean	*+0.29*	*+0.06*	*−0.11*		*−0.08*	*+0.05*	*−0.08*
FINE SANDS							
8 Brigg I	+0.90	+1.10	−0.26	±0.797	−0.16	−0.08	+0.09
9 Bury II	−0.02	+0.78	+0.34	±0.398	+0.13	+0.42	−0.06
10 Ipswich	—	—	—	—	−0.18	−0.30	−0.28
11 Kidderminster I ..	+0.62	−0.16	−0.03	±0.539	−0.26	−0.28	−0.02
12 King's Lynn II.. ..	−0.06	−0.80	+0.06	±0.710	+0.12	+0.18	+0.22
13 Spalding	+1.16	−0.10	−1.54	±1.43	+0.26	−0.05	−0.42
Mean	*+0.52*	*+0.16*	*−0.29*		*−0.02*	*−0.02*	*−0.08*
LIGHT LOAMS							
14 Allscott II	−1.03	+0.44	−0.72	±1.46	+0.02	−0.12	−0.27
15 Bardney I	−0.34	−0.04	+0.80	±0.641	+0.25	+0.01	+0.12
16 Cantley II	+0.52	−0.45	−0.62	±0.419	−0.60	−0.06	−0.36
17 King's Lynn I	−0.12	−0.28	+0.36	±0.373	−0.08	+0.07	−0.10
18 Newark I	−0.16	−1.04	−0.18	±0.501	−0.06	+0.28	+0.06
19 Peterboro' I	—	—	—	—	+0.14	+0.11	−0.12
20 Poppleton I	−1.16	−0.06	+0.93	±0.566	−0.20	+0.22	−0.12
21 Poppleton II	+0.15	−0.04	+1.79**	±0.491	+0.17	+0.33	−0.36
22 Selby I	+1.02	−0.10	−0.42	±0.751	+0.60	+0.43	+1.02
23 Wissington III ..	−0.06	+0.02	+0.09	±0.612	+0.25	+0.07	−0.09
Mean	*−0.13*	*−0.17*	*+0.23*		*+0.05*	*+0.13*	*−0.02*
HEAVY LOAM							
24 Colwick	+0.30	−0.18	+0.27	±0.457	+0.02	+0.08	+0.10
CLAY LOAMS							
25 Felstead I	−0.33	+0.55	−0.64	±0.325	+0.15	+0.10	−0.08
26 Felstead II	+0.68	−1.18	+0.26	±0.872	−0.28	+0.16	−0.46
27 Rothamsted I	−0.04	+0.70	−0.44	±0.612	−0.08	+0.08	−0.23
28 Selby II..	—	—	—	—	−0.30	−0.22	+0.02
Mean	*+0.10*	*+0.02*	*−0.27*		*−0.13*	*+0.03*	*−0.19*
FENS							
29 Ely	+1.66	+0.99	−1.01	±0.987	+0.14	−0.18	+0.21
30 Peterboro' II	—	—	—	—	+0.50	+0.34	+0.26
Mean	*+1.66*	*+0.99*	*−1.01*		*+0.32*	*+0.08*	*+0.24*
Mean	*+0.21*	*+0.02*	*−0.06*		*0.00*	*+0.06*	*−0.05*

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
	PLANT NUMBER: thousands per acre			PERCENTAGE PURITY		
COARSE SANDS						
1 Allscott I	−0.1	−1.2	+0.1	—	—	—
2 Bardney II	+2.1	−1.7	+1.4	+0.2	−0.6	−0.9
3 Brigg II	+0.7	−1.6	+0.1	—	—	—
4 Bury I	+1.8	+1.6	−0.8	+0.5	+0.8	−0.6
5 Cantley I	−1.8	−1.8	−0.5	−1.2	0.0	−0.8
6 Tunstall	+0.7	−2.0	−0.8	—	—	—
7 Wissington II	+0.3	−0.2	+0.4	−0.4	−0.2	−0.2
Mean	*+0.5*	*−1.0*	*0.0*	*−0.2*	*0.0*	*−0.6*
FINE SANDS						
8 Brigg I	+1.5	+2.4	+0.2	—	—	—
9 Bury II	+1.4	+0.8	−0.8	+0.2	+0.4	−0.1
10 Ipswich	+1.2	+0.7	−0.8	—	—	—
11 Kidderminster I	−1.4	−0.9	0.0	−0.6	−0.2	+0.2
12 King's Lynn II	−0.4	0.0	0.0	+0.4	0.0	+0.2
13 Spalding	−0.4	+0.9	−0.3	+0.1	−0.4	−1.5
Mean	*+0.3*	*+0.6*	*−0.3*	*0.0*	*0.0*	*−0.3*
LIGHT LOAMS						
14 Allscott II..	−3.4	+4.8	−1.8	—	—	—
15 Bardney I	+0.6	−1.9	−0.4	+0.6	−1.4	−0.4
16 Cantley II	0.0	0.0	−0.4	−1.6	+0.8	−0.2
17 King's Lynn I	+0.4	+1.0	+1.4	−0.1	−0.2	−0.4
18 Newark I	−0.2	+1.0	+0.3	0.0	−0.4	−0.6
19 Peterboro' I	+0.2	+0.2	+1.2	—	—	—
20 Poppleton I	−1.4	+2.4	+4.2	+0.2	+0.4	−0.4
21 Poppleton II	0.0	−1.1	+1.0	−0.2	+0.1	−0.3
22 Selby I	0.0	+0.1	−0.6	+0.3	0.0	+0.4
23 Wissington III	−0.8	+0.9	+1.3	−0.3	+0.2	+0.2
Mean	*−0.5*	*+0.7*	*+0.6*	*−0.1*	*−0.1*	*−0.2*
HEAVY LOAM						
24 Colwick	−0.8	+1.2	−2.2	−0.2	+0.6	+0.6
CLAY LOAMS						
25 Felstead I	−0.9	+1.0	−0.3	+0.6	+0.8	0.0
26 Felstead II	+0.1	+1.6	+1.4	−0.2	0.0	−0.1
27 Rothamsted I	−1.5	−0.6	−0.6	—	—	—
28 Selby II	−0.2	−1.0	+4.0	−1.4	−0.4	−0.8
.. *Mean*	*−0.6*	*+0.2*	*+1.1*	*−0.3*	*+0.1*	*−0.3*
FENS						
29 Ely	−0.5	+0.8	−0.4	0.0	−0.1	+0.3
30 Peterboro' II	−0.6	+0.6	−0.8	—	—	—
Mean	*−0.6*	*+0.7*	*−0.6*	*0.0*	*−0.1*	*+0.3*
Mean	*−0.1*	*+0.3*	*+0.2*	*−0.1*	*0.0*	*−0.3*

Conclusions

Effects of sulphate of ammonia

The average response in total sugar to the double dressing of sulphate of ammonia was 5.2 cwt. per acre. This figure is considerably smaller than the mean response in 1936, but is about double the average response in the years 1933–1935.

The increases to sulphate of ammonia were significant at twenty of the thirty centres. Of the remaining centres, all showed positive responses except Spalding, which had the highest mean yield, Peterboro' I and the two fen soils, Ely and Peterboro' II. At Ely the depression due to sulphate of ammonia was almost significant. The additional response to the second dressing was smaller than the response to the first dressing at twenty of the twenty-six centres which showed a positive response, the falling off in response being significant at two centres.

Tops were weighed at twenty-four centres. The response to the double dressing of sulphate of ammonia was significant at the 1 per cent. level at all these centres except Allscott II, which also showed a positive response. Even on the fen soil at Ely, tops responded significantly to sulphate of ammonia. The average response was 3.0 tons per acre, as against an average of 2.4 tons per acre in the four previous seasons. As usual, there was no regular falling off in effectiveness at the higher level of application. At Poppleton I there was a significant negative curvature and at Felstead II a significant positive curvature.

The responses in total sugar and tops varied significantly from centre to centre. There was, however, no indication that the responses were correlated with the type of soil or with the mean yield, apart possibly from the failure of sulphate of ammonia to increase the total sugar on the two fen soils.

The effects of sulphate of ammonia on roots were similar to those on sugar, all centres showing an increase to the fertiliser except the two fen soils and Peterboro' I. Sulphate of ammonia also reduced the sugar percentage at twenty-six centres, the mean reduction being 0.31 per cent., somewhat smaller than the average in previous years. The effects on percentage purity were small. Plant numbers were increased on all the coarse sands, but elsewhere sulphate of ammonia had little effect on plant numbers.

Effects of superphosphate

Superphosphate increased the total sugar at twenty-three centres, the increase being significant at five centres. The average response to the double dressing was 1.9 cwt. per acre compared with an average of 1.2 cwt. for the four previous years. There was a very large response at Allscott II on poor soil. The response decreased at the higher level of application at all five centres which showed a clear response, the average curvature at these centres being significant. Superphosphate increased the yield of tops at eighteen of the twenty-four centres where tops were weighed, significant responses occurring at four centres. There was a significant negative curvature at Allscott II, which gave the largest response to superphosphate in tops, but at other centres there was no consistent falling off in response with the double dressing.

The responses in total sugar and tops varied significantly from centre to centre, but this result was due entirely to the large response at Allscott II ; if this centre is omitted the responses at remaining centres do not vary at all abnormally. It may be noted, however, that the largest responses to superphosphate in sugar all occurred at centres with moderate or low mean yields.

The average effects of superphosphate on percentage purity and plant number were small.

Effects of muriate of potash

The responses to muriate of potash were larger this year than in any previous year, the mean response over all centres being 2.8 cwt. of sugar per acre. All except two centres showed a positive response and seven centres gave significant responses. There was little indication on the average of a drop in effectiveness at the higher level of dressing, even amongst the centres which showed the largest responses. The large positive curvature at Peterboro' II was due to an anomalous depression of yield by the single dressing of muriate of potash. The responses in sugar per acre varied significantly from centre to centre. The depressions found in 1936 on the heavy and clay loams did not appear this year, but the average response to potash on these soils was only about a third of that on other types of soil.

Tops were increased at twenty out of twenty-four centres, the increase being significant at Poppleton I. There was no apparent falling-off in response with the double dressing.

The effects on roots were similar to those on sugar. Sugar percentage was increased at most centres. The average increase was 0.27 per cent, which is almost equal to the average increase in the four previous years. Percentage purities were increased by more than 1 per cent. at four centres, but the average effect over all centres which took this measurement was small. The effects on plant numbers were similarly small, apart from a striking increase of 7.0 thousands per acre on a very dense crop at Tunstall.

Interactions

There was a significant positive interaction in total sugar between sulphate of ammonia and muriate of potash on the average of all centres. Two centres, Bury II and Felstead I, gave individually significant positive interactions.

The other interactions were small and not significant.

EXPERIMENTS AT OUTSIDE CENTRES

Barley. Bracken Farm, Tunstall, Suffolk, 1937. A. W. Oldershaw, Esq., County Organiser

3 randomised blocks of 9 plots each. Plots 1/40 acre.

TREATMENTS : 3×3 factorial design.

No phosphate, superphosphate and slag (15.7% total P_2O_5) at the rate of 1.0 cwt. P_2O_5 per acre; no lime, limestone and dolomite at the rate of 2 tons per acre, all applied to the previous crop of sugar beet in 1936.

BASAL MANURING : Nil.

SOIL : Coarse sand. Manures applied : Limestone and dolomite : March 20, 1936. Artificials : April 21, 1936. Seed sown : March 26. Harvested : Aug. 19. Previous crop : Sugar beet. (See 1936 Report p.266).

SPECIAL NOTE : Total produce was weighed on the field. Two random samples per plot were taken from the swathes to determine the ratio of grain to total produce.

STANDARD ERROR PER PLOT : Grain : 0.799 cwt. per acre or 14.7%.

	None	Limestone	Dolomite	*Mean*	*Increase*
	GRAIN : cwt. per acre (±0.461. *Means: ±0.266. Increases: ±0.376*)				
None ..	6.0	5.6	5.0	*5.5*	
Super. ..	5.3	5.1	6.4	*5.6*	*+0.1*
Slag ..	5.1	6.0	4.5	*5.2*	*−0.3*
Mean ..	*5.5*	*5.6*	*5.3*	*5.4*	
Increase ..		*+0.1*	*−0.2*		
	STRAW : cwt. per acre				
None ..	8.8	9.0	7.6	*8.5*	
Super. ..	8.8	8.6	9.3	*8.9*	*+0.4*
Slag ..	8.1	8.7	8.3	*8.4*	*−0.1*
Mean ..	*8.6*	*8.8*	*8.4*	*8.6*	
Increase ..		*+0.2*	*−0.2*		

Conclusions

The yield was a poor one, and there were no significant residual effects of the 1936 treatments.

Barley. South-Eastern Agricultural College, Wye, Kent, 1937

6×6 Latin square. Plots : 1/120 acre.

TREATMENTS : 3×2 factorial design.

No nitrogen : Sulphate of ammonia or nitro-chalk, both at 0.2 cwt. N per acre.

Superphosphate : None, 0.4 cwt. P_2O_5 per acre.

BASAL MANURING : Nil.

SOIL : Loam. Variety : Plumage Archer. Manures applied : April 1. Seed Sown : April 1. Harvested : Aug. 13. Previous crop : Wheat.

SPECIAL NOTE : Total produce was weighed on the field. Two random samples (each 1 metre × 4 rows) per plot were taken from the standing crop to determine the ratio of grain to total produce.

STANDARD ERROR PER PLOT : Grain : 1.22 cwt. per acre or 8.30%.

	None	Sulphate of ammonia	Nitro-chalk	*Mean* (±*0.288*)	*Increase* (±*0.407*)
	GRAIN: cwt. per acre (±0.498)				
None	9.8	16.1	17.7	*14.5*	
Super.	11.1	16.3	17.4	*14.9*	*+0.4*
Mean (±*0.352*) ..	*10.4*	*16.2*	*17.6*	*14.7*	
Increase (±*0.498*) ..		*+5.8*	*+7.2*		
	STRAW: cwt. per acre				
None	11.7	19.5	19.8	*17.0*	
Super.	12.7	17.7	20.9	*17.1*	*+0.1*
Mean	*12.2*	*18.6*	*20.4*	*17.1*	
Increase		*+6.4*	*+8.2*		

Conclusions

There was a significant response in grain to nitrogen, the response being significantly greater for nitro-chalk than for sulphate of ammonia. The response in grain to superphosphate was small and not significant. The effects on straw were similar.

Clover. Tunstall, Suffolk, 1937

A. W. Oldershaw, Esq., County Organiser

5 × 5 Latin square. Plots: 0.01784 acre.

TREATMENTS: Sixth year, no further chalk applied (see 1932 Report, p. 208, for first year's dressings).

BASAL MANURING: Nil.

SOIL: Poor sand. Variety: Broad red. Seed sown: Spring, 1936. Cut June 8, 1937. Previous crop: Barley.

STANDARD ERROR PER PLOT: 2.32 cwt. per acre or 7.81%.

Chalk tons per acre (1932)	HAY cwt. per acre	*Increase*
Mean	*29.7*	
0	5.0	
1	32.3	+ *27.3*
2	34.9	+ *2.6*
3	37.4	+ *2.5*
4	38.8	+ *1.4*
St. errors	±1.04	± *1.47*

Conclusions

The plots receiving no chalk in 1932 gave very small yields. The higher dressings of chalk in 1932 continued to give significantly higher yields than the first dressing. There was a slight falling off in response at the highest dressing, though this was not statistically significant.

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Potatoes. W. E. Morton, Esq., Gores Farm, Thorney, 1937

3 randomised blocks of 9 plots each, certain second order interactions being confounded with block differences. Plots : 1/60 acre.

TREATMENTS : 3×3×3 factorial design.

Sulphate of ammonia : None, 0.3, 0.6 cwt. N per acre.

Superphosphate : None, 0.75, 1.50 cwt. P_2O_5 per acre.

Sulphate of potash : None, 0.75, 1.50 cwt. K_2O per acre.

BASAL MANURING : Dung.

SOIL : Shallow black fen. Variety : Scotch King Edward. Manures applied : May 4. Potatoes planted : May 6. Lifted : Oct. 1. Previous crop : Wheat.

SPECIAL NOTE : 1 cwt. of potatoes from each plot was passed over a 1½ inch riddle to determine the percentage ware.

STANDARD ERRORS PER PLOT : Total produce : 1.20 tons per acre or 12.8%. Percentage ware : 5.41.

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 (±0.693. *Means : ±0.400. Increases : ±0.566*)								
0.0 cwt. N	8.62	7.55	8.40	7.20	8.10	9.28	*8.19*	
0.3 cwt. N	8.47	9.88	10.10	8.27	9.74	10.45	*9.49*	*+1.30*
0.6 cwt. N	9.35	10.82	10.63	9.49	9.71	11.60	*10.27*	*+0.78*
Mean	*8.81*	*9.42*	*9.71*	*8.32*	*9.18*	*10.44*	*9.32*	
Increase		*+0.61*	*+0.29*		*+0.86*	*+1.26*		
PERCENTAGE WARE : (±3.12. *Means : ±1.80. Increases : ±2.54*)								
0.0 cwt. N	76.2	75.6	68.7	68.4	73.2	78.8	*73.5*	
0.3 cwt. N	72.3	68.4	65.8	66.9	65.8	73.8	*68.8*	*−4.7*
0.6 cwt. N	79.2	74.1	71.1	69.1	76.5	78.9	*74.8*	*+6.0*
Mean	*75.9*	*72.7*	*68.5*	*68.1*	*71.8*	*77.2*	*72.4*	
Increase		*−3.2*	*−4.2*		*+3.7*	*+5.4*		

Interaction of sulphate of potash with superphosphate

Sulphate of potash	TOTAL PRODUCE : tons per acre (±0.693) Superphosphate (cwt. P_2O_5) 0.00	0.75	1.50	PERCENTAGE WARE (±3.12) Superphosphate (cwt. P_2O_5) 0.00	0.75	1.50
0.00 cwt. K_2O	8.16	8.62	8.17	73.5	64.9	66.1
0.75 cwt. K_2O	8.06	8.97	10.52	74.1	74.1	67.3
1.50 cwt. K_2O	10.21	10.66	10.45	80.0	79.2	72.3

Conclusions

All three fertilizers increased the yield of total produce, the increases to the double dressings being 2.1 tons per acre with sulphate of ammonia, 0.9 tons per acre with superphosphate and 2.1 tons per acre with sulphate of potash. The increase to superphosphate was not large enough to be significant. The slight drop in response at the higher level of application with sulphate of ammonia was not nearly significant and with sulphate of potash there was no sign of a falling off in response. The response to sulphate of ammonia was somewhat greater in presence of superphosphate than in its absence, but not significantly so.

Sulphate of potash gave a significant increase in percentage ware, while superphosphate gave a significant decrease. The increase due to sulphate of ammonia was not significant.

Potatoes. W. E. Morton, Esq., Australia Farm, March, 1937

3 randomised blocks of 9 plots each, certain second order interactions being confounded with block differences. Plots : 1/60 acre.

TREATMENTS : 3 × 3 × 3 factorial design.

Sulphate of ammonia : None, 0.3, 0.6 cwt. N per acre.

Superphosphate : None, 0.75, 1.50 cwt. P_2O_5 per acre.

Sulphate of potash : None, 0.75, 1.50 cwt. K_2O per acre.

BASAL MANURING : Nil.

SOIL : Good quality Fenland near the clay. Variety : Scotch Majestic. Manures applied. May 4. Potatoes planted: May 7. Lifted : Oct. 26. Previous crop : Oats.

SPECIAL NOTE : 1 cwt of potatoes from each plot was passed over a 1⅝ inch riddle to determine the percentage ware.

STANDARD ERRORS PER PLOT : Total produce : 0.704 tons per acre or 4.85%. Percentage ware : 3.69.

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 (±0.406. *Means : ±0.234. Increases : ±0.331*)								
0.0 cwt. N	12.60	13.87	13.90	13.62	12.96	13.79	*13.46*	
0.3 cwt. N	12.96	15.20	16.23	14.34	14.49	15.56	*14.80*	*+1.34*
0.6 cwt. N	13.07	15.62	17.23	14.96	15.55	15.41	*15.31*	*+0.51*
Mean	*12.88*	*14.90*	*15.79*	*14.31*	*14.33*	*14.92*	*14.52*	
Increase		*+2.02*	*+0.89*		*+0.02*	*+0.59*		
PERCENTAGE WARE : (±2.13. *Means : ±1.23. Increases : ±1.74*)								
0.0 cwt. N	88.1	88.1	85.9	85.9	88.4	87.8	*87.4*	
0.3 cwt. N	91.1	84.4	83.2	84.4	88.4	85.9	*86.2*	*−1.2*
0.6 cwt. N	89.9	83.5	82.9	85.0	85.0	86.2	*85.4*	*−0.8*
Mean	*89.7*	*85.3*	*84.0*	*85.1*	*87.3*	*86.6*	*86.3*	
Increase		*−4.4*	*−1.3*		*+2.2*	*−0.7*		

Interaction of sulphate of potash with superphosphate

Sulphate of potash	TOTAL PRODUCE : tons per acre (±0.406) Superphosphate (cwt. P_2O_5) 0.00	0.75	1.50	PERCENTAGE WARE (±2.13) Superphosphate (cwt. P_2O_5) 0.00	0.75	1.50
0.00 cwt. K_2O	12.63	14.53	15.77	89.0	85.3	81.0
0.75 cwt. K_2O	13.04	14.99	14.97	89.3	84.1	88.4
1.50 cwt. K_2O	12.96	15.18	16.62	90.8	86.6	82.6

Conclusions

The yields of total produce were excellent, the mean being 14.5 tons per acre. Sulphate of ammonia and superphosphate produced significant increases in total yield, the increases to the double dressing being 1.8 tons per acre and 2.9 tons per acre respectively. In both cases the responses fell off significantly at the higher level of application. There was also a significant positive interaction between the two effects, the increase to sulphate of ammonia being 0.5 tons per acre in the absence of superphosphate and 3.3 tons per acre with the double dressing of superphosphate. Sulphate of potash gave a small increase which was not significant.

Superphosphate produced a significant decrease in percentage ware of 5.7 to the double dressing. Sulphate of ammonia also produced a slight, though not significant decrease, while potash had little effect.

Potatoes. F. G. Starling, Esq., Flanders Farm, Littleport, 1937

3 randomised blocks of 9 plots each, certain second order interactions being confounded with block differences.

PLOTS: 1/60 acre.

TREATMENTS: 3 × 3 × 3 factorial design.
Sulphate of ammonia: None, 0.3 cwt. N, 0.6 cwt. N per acre.
Superphosphate: None, 0.75 cwt. P_2O_5, 1.5 cwt. P_2O_5 per acre.
Sulphate of potash: None, 0.75 cwt. K_2O, 1.5 cwt. K_2O per acre.

BASAL MANURING: Light dressing of poor dung.

SOIL: Black Fen, clay subsoil. Variety: King Edward. Manures applied: April 14. Potatoes planted: April 14. Lifted: Oct. 12. Previous crop: Unknown (new farm).

SPECIAL NOTE: Potatoes passed over 1½ inch riddle to determine percentage ware.

STANDARD ERRORS PER PLOT: Total produce: 0.663 tons per acre or 4.70%. Percentage ware: 1.08.

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 (±0.383. *Means*: ±*0.221*. *Increases*: ±*0.312*)							
0.0 cwt. N	13.07	12.77	12.36	11.91	12.66	13.62	*12.73*	
0.3 cwt. N	13.62	14.27	15.06	14.25	14.20	14.51	*14.32*	*+1.59*
0.6 cwt. N	14.12	15.40	16.36	14.31	15.35	16.21	*15.29*	*+0.97*
Mean	*13.60*	*14.15*	*14.59*	*13.49*	*14.07*	*14.78*	*14.11*	
Increase	*+0.55*	*+0.44*		*+0.58*	*+0.71*			
	PERCENTAGE WARE: (±0.624. *Means*: ±*0.360*. *Increases*: ±*0.509*)							
0.0 cwt. N	93.6	92.5	93.7	92.7	93.7	93.5	*93.3*	
0.3 cwt. N	92.6	92.0	92.2	92.2	92.3	92.4	*92.3*	*−1.0*
0.6 cwt. N	90.8	90.0	91.6	92.1	90.3	90.0	*90.8*	*−1.5*
Mean	*92.3*	*91.5*	*92.5*	*92.3*	*92.1*	*92.0*	*92.1*	
Increase	*−0.8*	*+1.0*		*−0.2*	*−0.1*			

Interaction of sulphate of potash with superphosphate

Sulphate of potash	TOTAL PRODUCE tons per acre (±0.383) Superphosphate (cwt. P_2O_5) 0.00	0.75	1.50	PERCENTAGE WARE (±0.624) Superphosphate (cwt. P_2O_5) 0.00	0.75	1.50
0.00 cwt. K_2O	12.63	13.57	14.27	93.5	91.4	92.1
0.75 cwt. K_2O	13.74	13.91	14.55	91.7	91.5	93.1
1.50 cwt. K_2O	14.44	14.96	14.96	91.8	91.6	92.4

Conclusions

The yields of total produce were high, the mean being 14.1 tons per acre. Each of the three fertilizers produced significant increases, the increases per acre to the double dressings being 2.6 tons for sulphate of ammonia, 1.0 tons for superphosphate and 1.3 tons for sulphate of potash. With sulphate of ammonia there was a significant decrease in response at the higher level of application, but with superphosphate and sulphate of potash there was no indication of any such falling off in response.

There was also a significant positive interaction between the effects of sulphate of ammonia and superphosphate, the response to sulphate of ammonia being 1.0 tons per acre in the absence of superphosphate and 4.0 tons per acre with the double dressing of superphosphate.

The percentages of ware to total produce were also very high. Superphosphate and sulphate of potash had no appreciable effect on percentage ware, but sulphate of ammonia produced a significant decrease of 2.5 per cent. to the double dressing.

https://doi.org/10.23637/ERADOC-1-69

Potatoes. Tunstall, Suffolk, 1937
A. W. Oldershaw, Esq., County Organiser

8 randomised blocks of 4 plots each.

PLOTS : 1/98 acre.

TREATMENTS : 2^4 factorial design.
Superphosphate : None, 1.0 cwt. P_2O_5 per acre.
Sulphate of potash : None, 1.70 cwt. K_2O per acre.
Magnesium sulphate : None, 4.46 cwt. per acre.
Dung : None, 10 tons per acre.

BASAL MANURING : Sulphate of ammonia at the rate of 0.6 cwt. N per acre.

SOIL : Coarse sand. Variety : Scotch Majestic. Manures applied : April 26. Potatoes: planted : May 6. Lifted : Oct. 13 and 14. Previous crop : Sugar beet.

SPECIAL NOTE : Dung was applied to blocks of four plots.

STANDARD ERRORS PER PLOT : Total produce : 0.834 tons per acre or 13.2%. Percentage ware : 3.90.

Responses to Fertilisers

Mean yields : Total produce : 6.30 *tons ; Percentage ware :* 68.2

	Mean response	Differential responses							
		Super. Absent	Super. Present	Sulph. pot. Absent	Sulph. pot. Present	Mag. sulph. Absent	Mag. sulph. Present	Dung Absent	Dung Present
	TOTAL PRODUCE : tons per acre (±0.417. *Means : ±0.295*).								
Superphosphate	*+0.50*	—	—	+0.44	+0.56	+0.56	+0.44	+0.64	+0.36
Sulphate of potash	*+0.84*	+0.78	+0.90	—	—	+0.87	+0.81	+0.77	+0.91
Magnesium sulphate	*+0.17*	+0.24	+0.11	+0.20	+0.14	—	—	+0.48	−0.13
	PERCENTAGE WARE (±1.95. *Means : ±1.38*)								
Superphosphate	*−0.2*	—	—	−1.8	+1.4	−1.0	+0.5	−1.2	+0.7
Sulphate of potash	*+2.9*	+1.3	+4.5	—	—	+3.4	+2.4	+3.7	+2.1
Magnesium sulphate	*−1.0*	−1.8	−0.2	−0.5	−1.5	—	—	0.0	−1.9

Conclusions

Sulphate of potash produced a significant increase both in total produce and in percentage ware. The responses to superphosphate and magnesium sulphate were not significant. The effects of dung, applied to blocks of four plots each, were small.

The experiment was damaged by torrential rains in May, when much soil was washed away.

Sugar Beet. H. King, Esq., Shenstone, nr. Kidderminster, 1937
Kidderminster Beet Sugar Factory

3 randomised blocks of 9 plots each. Plots : 0.01789 acre.

TREATMENTS : $3 \times 3 \times 3$ factorial design.

Nitrogen : None, sulphate of ammonia, nitrate of soda at 0.6 cwt. N per acre.

Phosphate : None, superphosphate and slag at 1.0 cwt. P_2O_5 per acre.

Potash : None, muriate of potash at 0.6 cwt. and 1.2 cwt. K_2O per acre.

BASAL MANURING : Nil.

SOIL : Light sandy loam. Variety : Webb's No. 2. Manures applied : April 23 and May 6. Seed sown : May 7. Lifted : Nov. 12 and 13. Previous crop : Wheat.

STANDARD ERRORS PER PLOT : Total sugar : 5.04 cwt. per acre or 25.6%. Tops : 0.964 tons per acre or 18.6%. Mean dirt tare : 0.094.

Nitrogen	Phosphate: None	Phosphate: Super.	Phosphate: Slag	Muriate of potash (cwt. K_2O): 0.0	Muriate of potash (cwt. K_2O): 0.6	Muriate of potash (cwt. K_2O): 1.2	*Mean*	*Increase*
	TOTAL SUGAR: cwt. per acre ($\pm$2.91. *Means:* $\pm$*1.68.* *Increases:* $\pm$*2.38*)							
None	11.0	23.1	19.3	18.1	19.0	16.3	*17.8*	
Sulph. amm. ..	9.8	20.2	12.3	9.5	14.2	18.6	*14.1*	*−3.7*
Nitr. soda ..	25.8	28.7	27.2	22.1	33.3	26.3	*27.2*	*+9.4*
Mean	*15.5*	*24.0*	*19.6*	*16.6*	*22.2*	*20.4*	*19.7*	
Increase		*+8.5*	*+4.1*		*+5.6*	*−1.8*		
	ROOTS (washed): tons per acre							
None	3.25	6.61	5.55	5.27	5.46	4.68	*5.14*	
Sulph. amm. ..	2.93	6.02	3.65	2.91	4.28	5.41	*4.20*	*−0.94*
Nitr. soda	7.43	8.34	7.83	6.60	9.49	7.51	*7.87*	*+2.73*
Mean	*4.54*	*6.99*	*5.68*	*4.93*	*6.41*	*5.87*	*5.74*	
Increase		*+2.45*	*+1.14*		*+1.48*	*−0.54*		
	TOPS: tons per acre ($\pm$0.557. *Means:* $\pm$*0.322.* *Increases:* $\pm$*0.455*)							
None	3.12	4.40	4.08	3.83	4.20	3.57	*3.87*	
Sulph. amm. ..	3.18	5.52	4.49	3.26	4.62	5.32	*4.40*	*+0.53*
Nitr. soda	6.55	7.69	7.57	6.65	7.61	7.55	*7.27*	*+3.40*
Mean	*4.28*	*5.87*	*5.38*	*4.58*	*5.48*	*5.48*	*5.18*	
Increase		*+1.59*	*+1.10*		*+0.90*	*0.00*		
	SUGAR PERCENTAGE							
None	16.90	17.50	17.33	17.17	17.43	17.13	*17.24*	
Sulph. amm. ..	16.67	16.63	16.73	16.20	16.63	17.20	*16.68*	*−0.56*
Nitr. soda	17.37	17.20	17.30	16.80	17.53	17.53	*17.29*	*+0.05*
Mean	*16.98*	*17.11*	*17.12*	*16.72*	*17.20*	*17.29*	*17.07*	
Increase		*+0.13*	*+0.14*		*+0.48*	*+0.09*		
	PLANT NUMBER: thousands per acre							
None	22.8	20.6	25.0	22.8	21.3	24.4	*22.8*	
Sulph. amm. ..	10.1	26.6	14.6	16.8	18.1	16.5	*17.1*	*−5.7*
Nitr. soda	23.1	30.7	23.4	24.4	27.9	25.0	*25.8*	*+3.0*
Mean	*18.7*	*26.0*	*21.0*	*21.3*	*22.4*	*22.0*	*21.9*	
Increase		*+7.3*	*+2.3*		*+1.1*	*−0.4*		
	PERCENTAGE PURITY							
None	88.4	88.5	88.6	88.4	88.8	88.2	*88.5*	
Sulph. amm. ..	88.8	88.3	88.1	88.2	88.2	88.9	*88.4*	*−0.1*
Nitr. soda	88.1	88.0	88.5	88.0	88.5	88.2	*88.2*	*−0.3*
Mean	*88.4*	*88.3*	*88.4*	*88.2*	*88.5*	*88.4*	*88.4*	
Increase		*−0.1*	*0.0*		*+0.3*	*−0.1*		

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Muriate of potash (cwt. K_2O)	None	Super.	Slag	None	Super.	Slag
	TOTAL SUGAR : cwt. per acre ($\pm$2.91)			ROOTS (washed) : tons per acre		
0.0	15.3	19.1	15.3	4.53	5.70	4.56
0.6	15.9	30.0	20.7	4.58	8.73	5.92
1.2	15.5	23.0	22.7	4.50	6.54	6.55
	TOPS: tons per acre ($\pm$0.557)			SUGAR PERCENTAGE		
0.0	4.53	4.38	4.82	16.73	16.67	16.77
0.6	3.98	6.99	5.46	17.20	17.10	17.30
1.2	4.33	6.25	5.86	17.00	17.57	17.30
	PLANT NUMBER : thousands per acre			PERCENTAGE PURITY		
0.0	20.6	26.2	17.1	88.3	87.6	88.7
0.6	17.4	24.7	25.0	88.6	88.6	88.3
1.2	18.1	26.9	20.9	88.4	88.7	88.3

Conclusions

The soil was acid (Ph4.6). The yields were low and the standard errors high. Sulphate of ammonia depressed the plant number and the yield of total sugar. Nitrate of soda increased the total sugar significantly by 9.4 cwt. per acre.

Superphosphate increased total sugar by 8.5 cwt. per acre and basic slag by 4.1 cwt. per acre, the last response not being significant.

The single dressing of muriate of potash produced a significant increase of 5.6 cwt. per acre in total sugar, but there was no further response to the double dressing.

The effects on tops were similar, except that sulphate of ammonia produced a slight, though not significant, increase.

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EXPERIMENTS CARRIED OUT BY LOCAL WORKERS

Hay. 2nd Season. Redericks Farm, Harlow, 1937

H. W. Gardner, Esq., Hertfordshire Farm Institute, St. Albans

6 randomised blocks of 6 plots each. Certain interactions partially confounded with block differences. Plots : 1/50 acre.

TREATMENTS : 3×3×2 factorial design.
Phosphate : High soluble slag, superphosphate and mineral phosphate at the rate of 0, 0.75 and 1.50 cwt. P_2O_5 per acre.
Muriate of potash : None, 0.5 cwt. K_2O per acre.

BASAL MANURING : Nil.

SOIL : Heavy loam. Manures applied : Dec. 18, 1935. Hay cut : June 24.

STANDARD ERROR PER PLOT : 4.86 cwt. per acre or 15.2%.

Summary of results, cwt. per acre : (±2.43*)

Cwt. P_2O_5	Slag	Super.	Mineral phosphate	*Mean (±1.40)*	*Increase (±1.98)*
0.00 ..		30.0[1]		*30.0*	
0.75 ..	34.4	33.6	29.8	*32.6*	*+2.6*
1.50 ..	29.6	34.8	35.0	*33.1*	*+0.5*
Mean (±1.72)	*32.0*	*34.2*	*32.4*	*31.9*	

Standard error : (1) ±1.40.

*This standard error applies to comparisons that are not confounded.

Muriate of potash (±1.98)	Phosphate (cwt. P_2O_5) 0.00	0.75	1.50	Slag	Super.	Mineral phosphate	*Mean (±1.14)*	*Increase (±1.61)*
None	29.9	36.0	31.0	28.8	34.4	33.8	*32.3*	
0.5 cwt. K_2O per acre	30.1	29.1	35.2	31.8	32.5	30.1	*31.5*	*−0.8*

Conclusions

The response to phosphate applied in December 1935 was not significant. There was no apparent response to muriate of potash applied in 1935.

Hay. 1st. Season. Burford Grammar School, Burford, Oxfordshire, 1937

5×5 Latin square. Plots : 1/160 acre.

TREATMENTS : No slag, slag at the rate of 1/3 cwt. and 1 cwt. P_2O_5 per acre. The object of this experiment is to compare annual dressings of 1/3 cwt. P_2O_5 with dressings of 1 cwt. every third year.

BASAL MANURING : Nil.

SOIL : Stone brash. Phosphate applied : April 22-28. Hay cut : June 16-18.

STANDARD ERROR PER PLOT : 3.52 cwt. per acre or 5.09%.

Superphosphate	Cwt.	*Increase*
Mean	*69.2*	
None	69.1[1]	
One-third dressing	68.3	*−0.8*
Full dressing	70.6	*+2.3*
St. errors	±1.57	*±2.22*

(1) ±0.909.

Conclusions

No significant effects.

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Hay. 7th Season. Lady Manner's School, Bakewell, 1937

3 randomised blocks of 8 plots each. Plots : 1/138 acre.

TREATMENTS : 2^3 factorial design.
Nitrate of soda : None, 2 cwt. per acre.
Superphosphate 13.7% : None, 3 cwt. per acre.
Potash salt 30% : None, 1 cwt. per acre.

BASAL MANURING : Nil.

SOIL : Limestone. Manures applied : April 7 and 8. Hay cut : June 23 and 24.

STANDARD ERROR PER PLOT : 7.79 cwt. per acre or 14.6%.

Responses to fertilisers : cwt. per acre

Mean yield : 53.2 cwt.

	Mean response (±*3.18*)	Differential responses (±4.50) Nitrate of soda Absent	Nitrate of soda Present	Superphosphate Absent	Superphosphate Present	Potash salt Absent	Potash salt Present
Nitrate of soda	+*16.5*	—	—	+15.6	+17.3	+15.4	+17.6
Superphosphate	+ *5.7*	+4.9	+6.6	—	—	+0.7	+10.8
Potash salt	+ *4.7*	+3.6	+5.8	−0.4	+9.7	—	—

Conclusions

There was a large response to nitrate of soda. Superphosphate and potash salt each gave a significant response in presence of the other, but no response in its absence.

Meadow Hay. 6th Season. Lady Manner's School, Bakewell, 1937

4 randomised blocks of 9 plots each. Plots : 1/202 acre.

TREATMENTS : 3 × 3 factorial design.
No manure, 8 tons compost, mixed artificials applied in 1933, 1935 and 1937, or in 1932, 1934 and 1936.
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 : April 8. Hay cut : July 5.

STANDARD ERROR PER PLOT : 5.16 cwt. per acre or 7.33%.

Summary of results, cwt. per acre (±2.58)

1933, 1935 and 1937 treatments	1932, 1934 and 1936 treatments Nil	NPK	Compost	*Mean* (±*1.49*)	*Increase* (±*2.11*)
Nil	53.6	56.8	67.0	*59.1*	
NPK	80.8	82.3	80.5	*81.2*	+*22.1*
Compost	74.3	69.1	70.0	*71.1*	+*12.0*
Mean (±*1.49*)	*69.6*	*69.4*	*72.5*	*70.5*	
Increase (±*2.11*) ..		−*0.2*	+*2.9*		

Conclusions

Complete artificials applied in 1937 increased the yield of hay by 22.1 cwt. per acre, while compost applied in 1937 gave an average increase of 12.0 cwt. per acre. The extra increase due to artificials was significant. Where no manuring was given in 1937, compost applied in 1936 increased the yield by 13.4 cwt. and artificials applied in 1936 by 3.2 cwt., the residual effect of compost on these plots being significantly greater than the residual effect of artificials. On the plots which received manures in 1937 there was little indication of a residual effect either of compost or artificials.

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Hay. 4th Season. Rowley Green Farm, Arkeley, Barnet, Herts, 1937
H. W. Gardner, Esq., Hertfordshire Farm Institute, St. Albans

6 randomised blocks of 6 plots each Certain interactions partially confounded with block differences. Plots : 1/50 acre.

TREATMENTS : 3×2^2 factorial design.
Phosphate : None, high soluble slag and gafsa phosphate at the rate of 1 cwt. P_2O_5 per acre.
30% Potash salt : None, 0.5 cwt. K_2O per acre.
Chalk : None, 75 cwt. per acre.

BASAL MANURING : Nil.

SOIL : Acid clay. Chalk applied : Jan. 30, 1934. Minerals applied : Feb. 6, 1934. Hay cut July 3.

STANDARD ERROR PER PLOT : 2.76 cwt. per acre or 10.7%.

Responses to fertilisers : cwt. per acre
Mean yield : 25.7 cwt.

	Mean response	Differential responses: Chalk Absent	Chalk Present	Potash Absent	Potash Present	No phosphate	Slag	Safsa phosphate
Chalk	*+5.9*[1]	—	—	+6.3[3]	+5.5[3]	+4.8[4]	+5.0[4]	+7.9[4]
Potash	*+1.2*[1]	+1.6[3]	+0.8[3]	—	—	+1.1[4]	+0.5[4]	+2.0[4]
Slag	*+0.7*[2]	+0.6[4]	+0.8[4]	+1.0[4]	+0.4[4]	—	—	—
Mineral phosphate	*−1.0*[2]	−2.5[4]	+0.6[4]	−1.4[4]	−0.6[4]	—	—	—

Standard errors : (1) ±0.918, (2) ±1.12, (3) ±1.38, (4) ±1.59.

Conclusions

There was a significant response of 5.9 cwt. per acre to chalk applied in 1934. There were no other significant effects.

Potatoes. Midland Agricultural College, Loughborough, 1937

4×4 Latin square. Plots : 0.0208 acre.

TREATMENTS : Increasing levels of a mixed fertiliser containing 3 cwt. superphosphate, 2 cwt. sulphate of potash and 2 cwt. sulphate of ammonia as shown below.

BASAL MANURING : 16 tons of farmyard manure per acre.

SOIL : Light loam. Variety : Arran Consul. Manures applied : April 29. Potatoes planted : April 30 and May 1. Lifted : Oct. 6-13. Previous crop : Seeds.

SPECIAL NOTE : Potatoes passed over a $1\frac{5}{8}$ inch riddle to determine percentage ware.

STANDARD ERRORS PER PLOT : Total produce : 0.937 tons per acre or 7.75%. Percentage ware : 1.83.

Artificials cwt. per acre	TOTAL PRODUCE tons per acre	*Increase for each dressing*	PERCENTAGE WARE	*Increase for each dressing*
Mean	*12.10*		*85.0*	
0	11.02		84.4	
4	12.61	*+1.59*	86.8	*+2.4*
8	12.39	*−0.22*	85.4	*−1.4*
12	12.36	*−0.03*	83.6	*−1.8*
St. errors	±0.468	*±0.662*	±0.916	*±1.30*

Conclusions

There was a significant increase in total produce to the first dressing (4 cwt. per acre) of mixed artificials, but no further increase to the higher dressings. The first dressing also gave the highest percentage ware.

Potatoes. H. Daulton, Esq., Ingham, Lincoln, 1937
Lindsey County Council, Education Committee

5×5 Latin square (Incomplete, 1 column not being recorded). Plots: 1/80 acre.

TREATMENTS: Increasing levels of a mixed fertiliser consisting of 6 parts sulphate of ammonia, 6 parts superphosphate (18%P_2O_5), 5 parts sulphate of potash and 1 part steamed bone flour as shown below.

BASAL MANURING: Nil.

SOIL: Cliff limestone. Variety: King Edward VII. Manures applied: April 1. Potatoes planted: April 4. Lifted: Oct. 8. Previous crop: Seeds.

SPECIAL NOTE: Potatoes passed over $1\frac{5}{8}$ inch riddle to determine percentage ware.

STANDARD ERRORS PER PLOT: Total produce: 0.624 tons per acre or 6.61%. Percentage ware 1.50.

Artificials cwt. per acre	TOTAL PRODUCE tons per acre	*Increase for each dressing*	PERCENTAGE WARE	*Increase for each dressing*
Mean	*9.45*		*82.5*	
0	7.51		82.0	
4	8.33	*+0.82*	80.6	*−1.4*
8	10.07	*+1.74*	82.3	*+1.7*
12	10.81	*+0.74*	83.0	*+0.7*
16	10.51	*−0.30*	84.5	*+1.5*
St. Errors	±0.312	*±0.441*	±0.752	*±1.06*

Conclusions

Mixed artificials produced a significant increase in total produce. The effectiveness of the artificials, however, decreased significantly with the higher dressings, there being no further increase in yield after the dressing of 12 cwt. per acre. Mixed artificials also produced a significant increase in percentage ware.

Potatoes. Messrs. Herring Bros., Welton, Lincoln, 1937
Lindsey County Council, Education Committee

5×5 Latin square. Plots: 1/80 acre.

TREATMENTS: Increasing levels of a mixed fertiliser consisting of 6 parts sulphate of ammonia, 6 parts 18% superphosphate, 5 parts sulphate of potash and 1 part of steamed bone flour as shown below.

BASAL MANURING: Nil.

SOIL: Limestone loam. Variety: King Edward VII. Manures applied: April 8. Potatoes planted: April 8. Lifted: Oct. 15. Previous crop: Seeds.

STANDARD ERRORS PER PLOT: Total produce: 0.475 tons per acre or 7.75%. Percentage ware: 2.04.

Artificials cwt. per acre	TOTAL PRODUCE tons per acre	*Increase for each dressing*	PERCENTAGE WARE	*Increase for each dressing*
Mean	*6.13*		*84.7*	
0	3.80		82.6	
4	5.15	*+1.35*	82.9	+0.3
8	6.36	*+1.21*	85.1	+2.2
12	7.29	*+0.93*	84.7	*−0.4*
16	8.04	*+0.75*	88.2	*+3.5*
St. Errors	±0.212	*±0.300*	±0.910	*±1.29*

Conclusions

Mixed artificials produced significant increases in both total produce and percentage ware. The successive increases in total produce decreased steadily as the level of manuring increased.

Sugar Beet. W. L. Wilson, Esq., Market Rasen, Lindsey County Council, 1937

Brigg Beet Sugar Factory

3 randomised blocks of 8 plots each, the plots being split for sulphate of ammonia at the rate of 3 cwt. per acre (April 16). Sub-plots : 1/100 acre.

TREATMENTS : No minerals, 5 cwt. 14% superphosphate and 3 cwt. 30% potash salt ploughed in (Feb. 4), broadcast after ploughing (March 22), broadcast in spring (April 16). No dung, 10 tons dung per acre (Feb. 3).

BASAL MANURING : Nil.

SOIL : Sandy loam. Variety : Kleinwanzleben E. Seed sown : April 26. Lifted : Oct. 16. Previous crop : Wheat.

STANDARD ERRORS : Total sugar : per whole plot : 2.58 cwt. per acre or 6.64% ; per sub-plot : 5.21 cwt. per acre or 13.4%. Tops : per whole plot : 0.385 tons per acre or 5.62% ; per sub-plot : 0.715 tons per acre or 10.4%. Mean dirt tare : 0.062.

TOTAL SUGAR : cwt. per acre (±1.49[1], ±2.13*)

	Minerals: None	Pl.† in	Broadcast March	Broadcast April	*Mean*	*Increase*
No Dung ..	32.8[1]	41.2[1]	41.9[1]	42.4[1]	*39.6[4]*	
Dung ..	35.8[1]	37.7[1]	39.6[1]	39.4[1]	*38.1[4]*	*−1.5[2]*
No sulph. amm.	29.4	34.6	36.6	34.6	*33.8[5]*	
Sulph. amm.	39.1	44.2	44.9	47.2	*43.8[5]*	*+10.0[6]*
Mean ..	*34.3[2]*	*39.4[2]*	*40.8[2]*	*40.9[2]*	*38.8*	
Increase ..		*+5.1[3]*	*+6.5[3]*	*+6.6[3]*		

St. errors (2) ±1.05, (3) ±1.49, (4) ±0.745, (5) ±1.06, (6) ±1.50.

ROOTS (washed) : tons per acre

	Minerals: None	Pl.† in	Broadcast March	Broadcast April	*Mean*	*Increase*
No Dung ..	9.04	11.28	11.40	11.40	*10.78*	
Dung ..	9.97	10.55	10.76	10.64	*10.48*	*−0.30*
No sulph. amm.	8.20	9.74	9.86	9.44	*9.31*	
Sulph. amm.	10.81	12.09	12.30	12.60	*11.95*	*+2.64*
Mean ..	*9.50*	*10.92*	*11.08*	*11.02*	*10.63*	
Increase ..		*+1.42*	*+1.58*	*+1.52*		

TOPS : tons per acre (±0.222[1], ±0.292*)

	Minerals: None	Pl.† in	Broadcast March	Broadcast April	*Mean*	*Increase*
No dung ..	6.53[1]	7.08[1]	7.20[1]	7.02[1]	*6.96[4]*	
Dung ..	6.70[1]	6.74[1]	6.72[1]	6.88[1]	*6.76[4]*	*−0.20[2]*
No sulph. amm.	5.36	6.10	6.06	6.04	*5.89[5]*	
Sulph. amm.	7.88	7.71	7.86	7.85	*7.82[5]*	*+1.93[6]*
Mean ..	*6.62[2]*	*6.91[2]*	*6.96[2]*	*6.95[2]*	*6.86*	
Increase ..		*+0.29[3]*	*+0.34[3]*	*+0.33[3]*		

St. errors (2) ±0.157, (3) ±0.222, (4) ±0.111, (5) ±0.146, (6) ±0.206.

SUGAR PERCENTAGE

	Minerals: None	Pl.† in	Broadcast March	Broadcast April	*Mean*	*Increase*
No dung ..	18.11	18.22	18.39	18.58	*18.32*	
Dung ..	17.92	17.83	18.42	18.44	*18.15*	*−0.17*
No sulph. amm.	17.96	17.79	18.58	18.30	*18.16*	
Sulph. amm.	18.06	18.26	18.24	18.72	*18.32*	*+0.16*
Mean ..	*18.02*	*18.02*	*18.41*	*18.51*	*18.24*	
Increase ..		*0.00*	*+0.39*	*+0.49*		

PLANT NUMBER : thousands per acre

	Minerals: None	Pl.† in	Broadcast March	Broadcast April	*Mean*	*Increase*
No dung ..	20.2	22.9	23.2	23.4	*22.4*	
Dung ..	21.2	20.0	19.8	21.0	*20.5*	*−1.9*
No sulph. amm.	19.8	20.7	21.2	21.4	*20.8*	
Sulph. amm.	21.6	22.2	21.9	23.0	*22.2*	*+1.4*
Mean ..	*20.7*	*21.4*	*21.6*	*22.2*	*21.5*	
Increase ..		*+0.7*	*+0.9*	*+1.5*		

† Pl. = Ploughed.
* For comparisons involving the difference of sulphate of ammonia and no sulphate of ammonia.

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	No dung	Dung	No dung	Dung
	TOTAL SUGAR: cwt. per acre ($\pm$1.50*)		ROOTS (washed): tons per acre	
No sulph. amm. ..	34.0	33.6	9.28	9.34
Sulph. amm. ..	45.1	42.6	12.28	11.62
	TOPS: tons per acre ($\pm$0.206*)		SUGAR PERCENTAGE	
No sulph. amm. ..	5.80	5.97	18.31	18.00
Sulph. amm. ..	8.10	7.55	18.34	18.30

PLANT NUMBER: thousands per acre

	No dung	Dung
No sulph. amm. ..	21.7	19.8
Sulph. amm. ..	23.2	21.1

Conclusions.

Minerals produced an average increase of 6.1 cwt. per acre in total sugar and 0.3 tons per acre in tops, the increase being significant in sugar but not quite significant in tops. There were no significant differences between the effects of different methods of applying the minerals. The response to minerals in sugar was significantly greater in the absence of dung than in its presence.

Dung increased the yield of total sugar in the absence of minerals, but in presence of minerals dung produced a significant decrease of 2.9 cwt. per acre. The effects of dung on tops were similar in direction, but very small.

Sulphate of ammonia gave significant increases of 10_0 cwt. per acre in sugar and 1.9 to nsper acre in tops.

Sugar Beet. G. A. Kilmister, Esq., Wragby, Lindsey County Council, 1937
Bardney Beet Sugar Factory

3 randomised blocks of 8 plots each, the plots being split for sulphate of ammonia at the rate of 3 cwt. per acre (May 4). Sub-plots: 0.01002 acre.

TREATMENTS: No minerals, 5 cwt. 14% superphosphate and 3 cwt. 30% potash salt, ploughed in (April 1), broadcast after winter ploughing (April 5), broadcast in spring (May 4). No dung, 10 tons dung per acre (Jan. 13 and 14).

BASAL MANURING: Nil.

SOIL: Heavy loam. Variety: Kleinwanzleben E. Seed sown: May 8. Lifted: Nov. 8. Previous crop: Wheat.

STANDARD ERRORS: Total sugar: per whole plot: 2.71 cwt. per acre or 5.60%; per sub-plot: 4.58 cwt. per acre or 9.46%. Tops: per whole plot: 0.375 tons per acre or 5.73%; per sub-plot: 1.10 tons per acre or 16.8%. Mean dirt tare: 0.307.

TOTAL SUGAR: cwt. per acre (±1.56[1], ±1.87*)

	None	Pl.† in	Minerals Broadcast April	Minerals Broadcast May	*Mean*	*Increase*
No dung ..	43.6[1]	49.8[1]	50.5[1]	45.3[1]	*47.3*[4]	
Dung ..	45.5[1]	50.8[1]	48.8[1]	52.8[1]	*49.5*[4]	*+2.2*[2]
No sulph. amm.	42.1	49.0	46.8	46.5	*46.1*[5]	
Sulph. amm.	47.0	51.6	52.4	51.6	*50.6*[5]	*+4.5*[6]
Mean ..	*44.6*[2]	*50.3*[2]	*49.6*[2]	*49.0*[2]	*48.4*	
Increase ..		*+5.7*[3]	*+5.0*[3]	*+4.4*[3]		

St. errors (2) ±1.10, (3) ±1.56, (4) ±0.780, (5) ±0. 935, (6) ±1.32.

ROOTS (washed): tons per acre

	None	Pl.† in.	Minerals Broadcast April	Minerals Broadcast May	*Mean*	*Increase*
No dung	12.10	13.69	14.01	12.54	*13.08*	
Dung	12.84	14.27	13.48	14.68	*13.82*	*+0.74*
No sulph. amm.	11.69	13.62	13.09	12.83	*12.81*	
Sulph. amm.	13.25	14.34	14.40	14.38	*14.09*	*+1.28*
Mean	*12.47*	*13.98*	*13.74*	*13.61*	*13.45*	
Increase		*+1.51*	*+1.27*	*+1.14*		

TOPS: tons per acre (±0.216[1], ±0.449*)

	None	Pl.† in	Minerals Broadcast April	Minerals Broadcast May	*Mean*	*Increase*
No dung ..	5.43[1]	6.26[1]	6.62[1]	6.40[1]	*6.18*[4]	
Dung ..	6.22[1]	6.90[1]	6.86[1]	7.66[1]	*6.91*[4]	*+0.73*[2]
No sulph. amm.	5.12	5.91	5.92	6.00	*5.74*[5]	
Sulph. amm.	6.52	7.26	7.55	8.06	*7.35*[5]	*+1.61*[6]
Mean ..	*5.82*[2]	*6.58*[2]	*6.74*[2]	*7.03*[2]	*6.54*	
Increase ..		*+0.76*[3]	*+0.92*[3]	*+1.21*[3]		

St. errors (2) ±0.153, (3) ±0.216, (4) ±0.108, (5) ±0.224, (6) ±0.317.

SUGAR PERCENTAGE

	None	Pl.† in.	Minerals Broadcast April	Minerals Broadcast May	*Mean*	*Increase*
No dung	18.03	18.18	17.98	18.05	*18.06*	
Dung	17.70	17.80	18.07	17.98	*17.89*	*−0.17*
No sulph. amm.	18.00	18.02	17.85	18.12	*18.00*	
Sulph. amm.	17.73	17.96	18.20	17.92	*17.95*	*−0.05*
Mean	*17.86*	*17.99*	*18.02*	*18.02*	*17.97*	
Increase		*+0.13*	*+0.16*	*+0.16*		

† Pl. = Ploughed.

* For comparisons involving the difference of sulphate of ammonia and no sulphate of ammonia.

PLANT NUMBER: thousands per acre

	None	Pl.† in	Minerals Broadcast April	Minerals Broadcast May	*Mean*	*Increase*
No dung ..	23.4	23.8	23.8	24.3	*23.8*	
Dung	23.8	23.8	23.8	24.4	*24.0*	*+0.2*
No sulph. amm. ..	23.2	23.7	23.9	23.9	*23.7*	
Sulph. amm. ..	24.0	23.9	23.6	24.8	*24.1*	*+0.4*
Mean	*23.6*	*23.8*	*23.8*	*24.4*	*23.9*	
Increase		*+0.2*	*+0.2*	*+0.8*		

	No dung	Dung	No dung	Dung
	TOTAL SUGAR: cwt. per acre (±1.32*)		ROOTS (washed): tons per acre	
No sulph. amm. ..	43.7	48.5	12.14	13.48
Sulph. amm. ..	50.9	50.4	14.03	14.16
	TOPS: tons per acre (±0.317*)		SUGAR PERCENTAGE	
No sulph. amm ...	5.18	6.31	18.00	17.99
Sulph. amm. ..	7.18	7.51	18.12	17.78

* For comparisons involving the difference of sulphate of ammonia and no sulphate of ammonia.

PLANT NUMBER: thousands per acre

	No dung	Dung
No sulph. amm.	23.8	23.6
Sulph. amm. ..	23.8	24.3

Conclusions

Minerals increased the yield of total sugar by 5.0 cwt. per acre and of tops by 1.0 tons per acre, both increases being significant. The differences produced by different ways of applying the minerals were not significant.

Sulphate of ammonia gave significant increases in total sugar and tops. Dung gave a significant increase in tops, but increased the yield of sugar only in the absence of sulphate of ammonia, the interaction between sulphate of ammonia and dung being almost significant.

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Sugar Beet. C. Coupland, Esq., East Kirkby, Lindsey County Council, 1937
Bardney Beet Sugar Factory
A. McVicar, Esq., County Organiser

3 randomised blocks of 8 plots each, the plots being split for sulphate of ammonia at the rate of 3 cwt. per acre (April 29). Sub-plots : 0.01002 acre.

TREATMENTS : No minerals, 5 cwt. 14 % superphosphate and 3 cwt. 30% potash salt, ploughed in (Jan 11), broadcast after winter ploughing (Jan. 20), broadcast in spring (April 29). Ploughed 7 or 11 inches deep.

BASAL MANURING : Nil.

SOIL : Sandy loam. Variety : Kleinwanzleben E. Seed sown : May 5. Lifted : Nov. 16 and 17. Previous crop : Tares.

STANDARD ERRORS : Total sugar : per whole plot : 3.00 cwt. per acre or 6.61% ; per sub-plot : 3.27 cwt. per acre or 7.21%. Tops : per whole plot : 0.558 tons per acre or 7.39% ; per sub-plot : 0.920 tons per acre or 12.2%. Mean dirt tare : 0.100.

TOTAL SUGAR : cwt. per acre (±1.73[1], ±1.34*)

	None	Pl.† in	Minerals Broadcast Jan.	April	*Mean*	*Increase*
Shallow ..	38.6[1]	47.8[1]	48.2[1]	42.8[1]	*44.4[4]*	
Deep	38.8[1]	49.6[1]	49.5[1]	47.4[1]	*46.3[4]*	*+1.9[2]*
No sulph. amm.	38.0	44.4	42.4	41.8	*41.6[5]*	
Sulph. amm.	39.4	53.0	55.2	48.2	*49.0[5]*	*+7.4[6]*
Mean ..	*38.7[2]*	*48.7[2]*	*48.8[2]*	*45.0[2]*	*45.3*	
Increase ..		*+10.0[3]*	*+10.1[3]*	*+6.3[3]*		

St. errors (2) ±1.22, (3) ±1.73, (4) ±0.865, (5) ±0.667, (6) ±0.944.

ROOTS (washed) : tons per acre

	None	Pl.† in	Minerals Broadcast Jan.	April	*Mean*	*Increase*
Shallow ..	10.82	13.40	13.42	11.74	*12.34*	
Deep	11.23	13.90	13.77	12.94	*12.96*	*+0.62*
No sulph. amm.	10.78	12.40	11.68	11.24	*11.52*	
Sulph. amm.	11.27	14.90	15.50	13.44	*13.78*	*+2.26*
Mean ..	*11.02*	*13.65*	*13.59*	*12.34*	*12.65*	
Increase ..		*+2.63*	*+2.57*	*+1.32*		

TOPS : tons per acre (±0.322[1], ±0.376*)

	None	Pl.† in	Minerals Broadcast Jan.	April	*Mean*	*Increase*
Shallow ..	7.23[1]	7.33[1]	7.53[1]	7.11[1]	*7.30[4]*	
Deep	7.85[1]	8.25[1]	7.45[1]	7.70[1]	*7.81[4]*	*+0.51[2]*
No sulph. amm.	6.20	6.60	5.60	6.02	*6.10[5]*	
Sulph. amm.	8.88	8.98	9.38	8.80	*9.01[5]*	*+2.91[6]*
Mean ..	*7.54[2]*	*7.79[2]*	*7.49[2]*	*7.41[2]*	*7.56*	
Increase ..		*+0.25[3]*	*−0.05[3]*	*−0.13[3]*		

St. errors (2) ±0.228, (3) ±0.322, (4) ±0.161, (5) ±0.188, (6) ±0.266.

SUGAR PERCENTAGE

	None	Pl.† in	Minerals Broadcast Jan.	April	*Mean*	*Increase*
Shallow ..	17.82	17.85	17.96	18.18	*17.95*	
Deep	17.28	17.84	17.96	18.28	*17.84*	*−0.11*
No sulph. amm.	17.62	17.88	18.12	18.55	*18.04*	
Sulph. amm.	17.48	17.80	17.82	17.92	*17.76*	*−0.28*
Mean ..	*17.55*	*17.84*	*17.96*	*18.24*	*17.90*	
Increase ..		*+0.29*	*+0.41*	*+0.69*		

PLANT NUMBER : thousands per acre

	None	Pl.† in	Minerals Broadcast Jan.	April	*Mean*	*Increase*
Shallow ..	30.0	30.8	30.0	30.3	*30.3*	
Deep	29.7	30.0	31.3	30.4	*30.4*	*+0.1*
No sulph. amm.	29.0	30.0	30.6	30.0	*29.9*	
Sulph. amm.	30.8	30.8	30.8	30.6	*30.8*	*+0.9*
Mean ..	*29.9*	*30.4*	*30.7*	*30.4*	*30.4*	
Increase ..		*+0.5*	*+0.8*	*+0.5*		

† Pl. = Ploughed.

* For comparisons involving the difference of sulphate of ammonia and no sulphate of ammonia.

	Shallow	Deep	Shallow	Deep
	TOTAL SUGAR: cwt. per acre (±0.944)		ROOTS (washed): tons per acre	
No sulph. amm. ..	40.9	42.4	11.26	11.80
Sulph. amm. ..	47.8	50.2	13.44	14.12
	TOPS: tons per acre (±0.266)		SUGAR PERCENTAGE	
No sulph. amm. ..	5.89	6.32	18.14	17.94
Sulph. amm. ..	8.71	9.30	17.77	17.74

PLANT NUMBER: thousands per acre

	Shallow	Deep
No sulph. amm. ..	30.2	29.6
Sulph. amm. ..	30.4	31.1

Conclusions

Minerals gave an average increase of 8.8 cwt. of sugar per acre, but had little effect on tops. The response in sugar to minerals was significantly greater with the January applications than with the April application, while ploughing in in January and broadcasting in January gave almost identical results. The response was also significantly greater in presence of sulphate of ammonia than in its absence.

Deep ploughing increased the yield of sugar by 1.9 cwt. per acre and that of tops by 0.5 tons per acre, the latter response being significant but not the former.

Sulphate of ammonia produced an average response of 7.4 cwt. per acre in sugar and 2.9 tons per acre in tops.

Sugar Beet. J. Chappell, Esq., Blyborough, Lindsey County Council, 1937

Brigg Beet Sugar Factory

3 randomised blocks of 8 plots each, the plots being split for sulphate of ammonia at the rate of 3 cwt. per acre (April 27). Sub-plots: 1/100 acre.

TREATMENTS: No minerals, 5 cwt. 14% superphosphate and 3 cwt. 30% potash salt, ploughed in (Jan. 27), broadcast after winter ploughing (Feb. 1), broadcast in spring (April 27). Ploughed 7 or 11 inches deep.

BASAL MANURING: Nil.

SOIL: Medium loam. Variety: Kleinwanzleben E. Seed sown: April 30. Lifted: Nov. 15. Previous crop: Wheat.

STANDARD ERRORS: Total sugar: per whole plot: 3.58 cwt. per acre or 6.87%; per sub-plot: 5.44 cwt. per acre or 10.4%. Tops: per whole plot: 0.534 tons per acre or 8.37%; per sub-plot: 0.608 tons per acre or 9.53%. Mean dirt tare: 0.105.

Ploughing	None	Pl.† in	Minerals Broadcast Feb.	Minerals Broadcast April	*Mean*	*Increase*	None	Pl.† in	Minerals Broadcast Feb.	Minerals Broadcast April	*Mean*	*Increase*
	TOTAL SUGAR : cwt. per acre (±2.07[1], ±2.22*)						ROOTS (washed) : tons per acre					
Shallow	49.2[1]	52.9[1]	52.7[1]	50.2[1]	*51.2[4]*		14.12	14.88	15.08	14.19	*14.57*	
Deep	50.2[1]	55.0[1]	54.6[1]	52.6[1]	*53.1[4]*	*+ 1.9[2]*	14.28	15.52	15.38	14.83	*15.00*	*+0.43*
No sul. amm.	43.2	47.6	47.8	46.0	*46.2[5]*		12.34	13.36	13.64	12.94	*13.07*	
Sulph. amm.	56.2	60.3	59.4	56.6	*58.1[5]*	*+11.9[6]*	16.06	17.04	16.82	16.08	*16.50*	*+3.43*
Mean	*49.7[2]*	*54.0[2]*	*53.6[2]*	*51.3[2]*	*52.1*		*14.20*	*15.20*	*15.23*	*14.51*	*14.78*	
Increase		*+4.3[3]*	*+3.9[3]*	*+1.6[3]*				*+1.00*	*+1.03*	*+0.31*		

St. errors (2) ±1.46, (3) ±2.07, (4) ±1.04, (5) ±1.11, (6) ±1.57.

Ploughing	None	Pl.† in	Minerals Broadcast Feb.	Minerals Broadcast April	*Mean*	*Increase*	None	Pl.† in	Minerals Broadcast Feb.	Minerals Broadcast April	*Mean*	*Increase*
	TOPS : tons per acre (±0.308[1], ±0.248*)						SUGAR PERCENTAGE					
Shallow	5.98[1]	6.34[1]	6.40[1]	6.38[1]	*6.28[4]*		17.45	17.76	17.46	17.67	*17.58*	
Deep	6.05[1]	6.50[1]	6.70[1]	6.68[1]	*6.48[4]*	*+0.20[2]*	17.56	17.70	17.72	17.72	*17.68*	*+0.10*
No sul. amm.	4.82	5.28	5.40	5.21	*5.18[5]*		17.49	17.78	17.54	17.78	*17.65*	
Sulph. amm.	7.22	7.56	7.72	7.84	*7.58[5]*	*+2.40[6]*	17.52	17.68	17.64	17.60	*17.61*	*−0.04*
Mean	*6.02[2]*	*6.42[2]*	*6.55[2]*	*6.53[2]*	*6.38*		*17.50*	*17.73*	*17.59*	*17.70*	*17.63*	
Increase		*+0.40[3]*	*+0.53[3]*	*+0.51[3]*				*+0.23*	*+0.09*	*+0.20*		

St. errors (2) ±0.218, (3) ±0.308, (4) ±0.154, (5) ±0.124, (6) ±0.176.

† Pl. = ploughed

* For comparisons involving the difference of sulphate of ammonia and no sulphate of ammonia

PLANT NUMBER : thousands per acre

Ploughing	None	Pl.† in	Minerals Broadcast Feb.	Minerals Broadcast April	*Mean*	*Increase*
Shallow ..	31.6	31.8	31.1	30.8	*31.3*	
Deep ..	30.1	32.3	31.4	31.1	*31.2*	*−0.1*
No sulph. amm.	30.2	31.2	31.0	30.9	*30.8*	
Sulph. amm.	31.4	32.9	31.4	31.0	*31.7*	*+0.9*
Mean ..	*30.8*	*32.0*	*31.2*	*31.0*	*31.2*	
Increase ..		*+1.2*	*+0.4*	*+0.2*		

	Shallow	Deep	Shallow	Deep
	TOTAL SUGAR : cwt. per acre (±1.57*)		ROOTS (washed) : tons per acre	
No sulph. amm. ..	46.3	46.0	13.12	13.02
Sulph. amm. ..	56.2	60.1	16.02	16.98
	TOPS : tons per acre (±0.176*)		SUGAR PERCENTAGE	
No sulph. amm. ..	5.15	5.20	17.64	17.66
Sulph. amm. ..	7.40	7.77	17.54	17.69

* For comparisons involving the difference of sulphate of ammonia and no sulphate of ammonia.

PLANT NUMBER : thousands per acre

	Shallow	Deep
No sulph. amm. ..	31.0	30.6
Sulph. amm. ..	31.6	31.8

Conclusions

Minerals produced an average increase of 3.3 cwt. per acre in total sugar and 0.5 tons per acre in tops, the increase in sugar being significant while that in tops was almost significant. The response in sugar to minerals was greater with the early applications than with the April application, but not significantly so.

The increases in total sugar and tops to deep ploughing over shallow ploughing were not significant.

Sulphate of ammonia increased total sugar by 11.9 cwt. per acre and tops by 2.4 tons per acre.

Sugar Beet. A. G. Revill, Esq., Pyewipe, Blyton, 1937
Brigg Beet Sugar Factory

R. Hull, Esq., Midland Agricultural College

6 randomised blocks of 6 plots each. Certain interactions partially confounded with block differences. Plots : 1/65 acre.

TREATMENTS : 3×2^2 factorial design.
No borax, 20, 40 lb. borax per acre applied before seeding or later in the season, without artificials or with artificials.
The artificials consisted of 3 cwt. nitrate of soda, 4 cwt. superphosphate and 2 cwt. muriate of potash per acre.

BASAL MANURING : Nil.

SOIL : Black sand. Variety : Kleinwanzleben E. Manures applied : April 8. Seed sown : April 23. Lifted : Nov. 8 and 9. Previous crop : Wheat.

SPECIAL NOTE : The intention was to apply the late dressing of borax when Heart Rot appeared but as none developed, the late dressing was not applied.

STANDARD ERRORS PER PLOT : Total sugar : 2.30 cwt. per acre or 4.72%. Tops : 1.05 tons per acre or 12.4%. Mean dirt tare : 0.023.

	TOTAL SUGAR		ROOTS (washed)		TOPS		SUGAR PERCENTAGE		PLANT NUMBER	
	Cwt.	*Incr.*	Tons	*Incr.*	Tons	*Incr.*		*Incr.*	Thous.	*Incr.*
Mean	*48.7*		*13.68*		*8.48*		*17.83*		*31.8*	
No artificials	42.1[1]		11.77		5.95[4]		17.89		31.6	
Artificials	55.4[1]	*+13.3*[7]	15.60	*+3.83*	11.01[4]	*+5.06*[10]	17.77	*−0.12*	31.9	*+0.3*
No Borax	48.3[2]		13.60		8.44[5]		17.76		31.8	
20 lb. Borax	48.9[3]	*+0.6*[8]	13.74	*+0.14*	8.37[6]	*−0.07*[11]	17.80	*+0.04*	31.5	*−0.3*
40 lb. Borax	50.4[3]	*+1.5*[9]	13.93	*+0.19*	8.78[6]	*+0.41*[12]	18.10	*+0.30*	31.8	*+0.3*

Standard errors: (1) ±0.542, (2) ±0.469, (3) ±0.939, (4) ±0.247, (5) ±0.214, (6) ±0.429. (7) ±0.766, (8) ±1.05, (9) ±1.33, (10) ±0,.349 (11) ±0.479, (12) ±0.607.

Interactions of Borax with Artificials

TOTAL SUGAR : cwt. per acre

	Borax (lb. per acre) None	20	40
None	43.2	42.9	41.9
Artificials	54.3	54.6	55.6

Conclusions

Artificials produced large responses in sugar per acre and tops. The response to the double dressing of borax was almost significant in sugar per acre, but borax had little effect on tops.

Neither artificials nor borax appeared to influence plant numbers.

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Sugar Beet. C. Bee, Esq., Digby Fen, 1937
R. Hull, Esq., Midland Agricultural College
and Bardney Beet Sugar Factory

4 randomised blocks of 6 plots each. Plots 1/65 acre.

TREATMENTS : 3×2 factorial design.

Manganese sulphate : None, 50 lb., 150 lb. per acre.

Nitrate of soda : None, 2 cwt. per acre.

BASAL MANURING : 4½ cwt. artificials consisting of 5 parts superphosphate and 2 parts muriate of potash.

SOIL : Black Fen. Variety : Johnsons. Manures applied : April 7. Seed sown : April 27. Lifted : Oct. 8-11. Previous crop : Barley.

STANDARD ERRORS PER PLOT : Total sugar : 2.54 cwt. per acre or 7.74%. Tops : 0.871 tons per acre or 9.61%.

Nitrate of soda	Manganese sulphate None	50 lb.	150 lb.	Mean	Increase	Manganese sulphate None	50 lb.	150 lb.	Mean	Increase
	TOTAL SUGAR : cwt. per acre (±1.27)					ROOTS (washed) : tons per acre				
None	28.4	31.4	35.9	*31.9*[1]		7.73	8.54	9.08	*8.45*	
2 cwt.	28.3	35.4	37.1	*33.6*[1]	*+1.7*[3]	7.44	8.99	9.60	*8.68*	*+0.23*
Mean	*28.4*[2]	*33.4*[2]	*36.5*[2]	*32.8*		*7.58*	*8.76*	*9.34*	*8.56*	
Increase		*+5.0*[4]	*+3.1*[4]				*+1.18*	*+0.58*		
	TOPS : tons per acre (±0.436)					SUGAR PERCENTAGE				
None	8.57	8.93	9.32	*8.94*[5]		18.30	18.40	19.78	*18.83*	
2 cwt.	8.57	9.46	9.52	*9.18*[5]	*+0.24*[7]	19.05	19.70	19.32	*19.36*	*+0.53*
Mean	*8.57*[6]	*9.20*[6]	*9.42*[6]	*9.06*		*18.68*	*19.05*	*19.55*	*19.10*	
Increase		*+0.63*[8]	*+0.22*[8]				*+0.37*	*+0.50*		

Standard errors : (1) ±0.733, (2) ±0.898, (3) ±1.04, (4) ±1.27, (5) ±0.252, (6) ±0.308, (7) ±0.356, (8) ±0.436.

Nitrate of soda	Manganese sulphate None	50 lb.	150 lb.	Mean	Increase
	PLANT NUMBER : thousands per acre				
None	30.3	28.0	29.3	*29.2*	
2 cwt.	26.8	28.2	28.2	*27.7*	*−1.5*
Mean	*28.6*	*28.1*	*28.8*	*28.5*	
Increase		*−0.5*	*+0.7*		

Conclusions

Manganese sulphate produced a significant increase in total sugar of 5.0 cwt. per acre to the 50 lb. dressing and 8.1 cwt. to the 150 lb. dressing. The response per unit of manganese sulphate was significantly less at the higher level of dressing than at the lower level. Manganese sulphate also produced a significant increase in tops, but had little effect on plant number.

The average responses in total sugar and tops to nitrate of soda were not significant, there being no response in the absence of manganese sulphate.

Sugar Beet. G. R. Taylor, Esq., Brough, 1937
Newark Beet Sugar Factory

4×4 Latin square. Plots : 0.02043 acre.

TREATMENTS : Increasing levels of a mixed fertiliser containing 5.1% phosphoric acid, 6.6% nitrogen and 10.0% potash as shown below.

BASAL MANURING : Nil.

SOIL : Sandy gravel. Variety : Kleinwanzleben E. Manures applied : April, 26. Seed sown : May 1. Lifted : November 8. Previous crop : Wheat.

STANDARD ERRORS PER PLOT : Total sugar : 2.97 cwt. per acre or 4.76%. Tops : 0.933 tons per acre or 11.0 %. Mean dirt tare : 0.118.

Artificials cwt. per acre	TOTAL SUGAR Cwt.	Increase	ROOTS (washed) Tons	Increase	TOPS Tons	Increase	SUGAR PER-CENTAGE	Increase	PLANT NUMBER Thous.	Increase
Mean	*62.4*		*16.47*		*8.46*		*18.96*		*37.5*	
0	51.0		13.40		5.53		19.00		36.9	
4	58.4	*+7.4*	15.26	*+1.86*	7.51	*+1.98*	19.15	*+0.15*	37.0	*+0.1*
8	69.2	*+10.8*	18.24	*+2.98*	8.95	*+1.44*	18.98	*−0.17*	37.8	*+0.8*
12	71.0	*+1.8*	18.99	*+0.75*	11.87	*+2.92*	18.70	*−0.28*	38.3	*+0.5*
St. errors	±1.48	*±2.09*			±0.466	*±0.659*				

Conclusions

The yields were high. There was a significant increase to mixed artificials in both total sugar and tops. The falling off in response at the highest level of application with sugar was not significant, and there was no sign of a falling off in response with tops.

Sugar Beet. W. Arden, Esq., Newton on Trent, 1937
Newark Beet Sugar Factory

4×4 Latin square. Plots : 0.02066 acre.

TREATMENTS : Increasing levels of a mixed fertiliser containing 5.1% phosphoric acid, 6.6% nitrogen and 10.0% potash as shown below.

BASAL MANURING : 12 loads farmyard manure per acre.

SOIL : Sand. Variety : Kleinwanzleben E. Manures applied : April 27. Seed sown : April 29. Lifted : Oct. 27. Previous crop : Carrots.

STANDARD ERRORS PER PLOT : Total sugar : 4.11 cwt. per acre or 5.60%. Tops : 2.45 tons per acre or 17.3%. Mean dirt tare : 0.122.

Artificials cwt. per acre	TOTAL SUGAR Cwt.	Increase	ROOTS (washed) Tons	Increase	TOPS Tons	Increase	SUGAR PER-CENTAGE	Increase	PLANT NUMBER Thous.	Increase
Mean	*73.4*		*19.07*		*14.15*		*19.25*		*31.3*	
0	66.5		17.25		11.66		19.30		31.8	
4	74.4	*+7.9*	19.36	*+2.11*	13.46	*+1.80*	19.20	*−0.10*	31.7	*−0.1*
8	72.4	*−2.0*	18.77	*−0.59*	15.09	*+1.63*	19.32	*+0.12*	30.6	*−1.1*
12	80.1	*+7.7*	20.90	*+2.13*	16.39	*+1.30*	19.18	*−0.14*	31.0	*+0.4*
St. errors	±2.06	*±2.91*			±1.22	*±1.73*				

Conclusions

The yields were high. There was a significant response to mixed artificials in both total sugar and tops. The apparent falling off in response with the higher dressings was not significant in either case.

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Sugar Beet. W. Bourne, Esq., North Muskham, 1937
Newark Beet Sugar Factory

4×4 Latin square. Plots : 0.02066 acre.

TREATMENTS : Increasing levels of a mixed fertiliser containing 5.1% phosphoric acid, 6.6% nitrogen and 10.0% potash as shown below.

BASAL MANURING : 10 loads of farmyard manure per acre.

SOIL : Sandy loam. Variety : Dippe. Manures applied : April 26. Seed sown : May 17. Lifted : Nov. 16. Previous crop : Peas.

STANDARD ERRORS PER PLOT : Total sugar : 2.48 cwt. per acre or 4.95%. Tops : 0.783 tons per acre or 10.0%. Mean dirt tare : 0.126.

Artificials cwt. per acre	TOTAL SUGAR Cwt.	*Increase*	ROOTS (washed) Tons	*Increase*	TOPS Tons	*Increase*	SUGAR PERCENTAGE	*Increase*	PLANT NUMBER Thous.	*Increase*
Mean	*50.0*		*13.38*		*7.79*		*18.67*		*44.4*	
0	42.3		11.30		5.91		18.70		44.4	
4	51.5	*+9.2*	13.64	*+2.34*	7.84	*+1.93*	18.87	*+0.17*	45.0	*+0.6*
8	50.4	*−1.1*	13.50	*−0.14*	7.65	*−0.19*	18.65	*−0.22*	44.1	*−0.9*
12	55.7	*+5.3*	15.09	*+1.59*	9.77	*+2.12*	18.45	*−0.20*	43.9	*−0.2*
St. errors	±1.24	*±1.75*			±0.392	*±0.554*				

Conclusions

Significant response to mixed artificials in both total sugar and tops, with some indication of a decrease in the responsiveness at the higher levels of application.

Sugar Beet. Messrs. Moore Brothers, Crowle, 1937
Brigg Beet Sugar Factory

4 randomised blocks of 8 plots each. Certain interactions partially confounded with block differences. Plots : 1/44 acre.

TREATMENTS : 4×2^2 factorial design.
Mixed artificials : None, 4 cwt., 8 cwt., 12 cwt., per acre.
Nitrate of soda : None, 1 cwt. per acre applied as top dressing on June 29.
Time of lifting : Early (Nov. 5 and 6), Late (Dec. 17).
The mixed artificials consisted of 3½ parts sulphate of ammonia, 3 parts nitrate of soda, 6½ parts superphosphate, 4 parts muriate of potash and 1 part steamed bone flour.

BASAL MANURING : Nil.

SOIL : Dark sand. Variety : Kleinwanzleben E. Manures applied : May 4. Seed sown : May 20. Previous crop : Oats.

STANDARD ERRORS PER PLOT : Total sugar : 3.45 cwt. per acre or 8.60%. Tops : 0.952 tons per acre or 7.57%.

Mean dirt tare : first lifting: 0.124, second lifting : 0.210.

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Nitrate of soda	Early	Late	*Mean*	*Increase*	Early	Late	*Mean*	*Increase*	Early	Late	*Mean*	*Increase*
	TOTAL SUGAR: cwt.				ROOTS (washed): tons				TOPS: tons			
None ..	40.8[1]	38.5[1]	*39.6*[2]		12.14	12.25	*12.20*		13.26[1]	11.17[1]	*12.22*[2]	
1 cwt. ..	41.0[1]	40.0[1]	*40.5*[2]	*+0.9*[1]	12.24	12.78	*12.51*	*+0.31*	13.76[1]	12.15[1]	*12.96*[2]	*+0.74*[1]
Mean ..	*40.9*[2]	*39.2*[2]	*40.0*		*12.19*	*12.52*	*12.36*		*13.51*[2]	*11.66*[2]	*12.59*	
Increase		*−1.7*[1]				*+0.33*				*−1.85*[1]		
Standard errors (1) ±1.22, (2) ±0.863									(1) ±0.337, (2) ±0.238.			
	SUGAR PERCENTAGE				PLANT NUMBER: thous.							
None ..	16.82	15.74	*16.28*		30.0	28.7	*29.4*					
1 cwt. ..	16.74	15.64	*16.19*	*−0.09*	30.8	27.4	*29.1*	*−0.3*				
Mean ..	*16.78*	*15.69*	*16.24*		*30.4*	*28.0*	*29.2*					
Increase		*−1.09*				*−2.4*						

	Mixed artificials: cwt. per acre 0	4	8	12	Mixed artificials: cwt. per acre 0	4	8	12
	TOTAL SUGAR: cwt. per acre (±1.72)				ROOTS (washed): tons per acre			
No nitrate of soda ..	34.5	40.7	42.0	41.6	10.68	12.43	13.04	12.64
Nitrate of soda ..	35.0	41.5	43.3	42.0	10.98	12.82	13.30	12.92
Early	35.3	41.2	42.0	45.2	10.76	12.13	12.49	13.36
Late	34.2	41.0	43.3	38.5	10.89	13.12	13.85	12.19
Mean	*34.8*[1]	*41.1*[1]	*42.6*[1]	*41.8*[1]	*10.83*	*12.62*	*13.17*	*12.78*
Increase		*+6.3*[2]	*+1.5*[2]	*−0.8*[2]		*+1.79*	*+0.55*	*−0.39*
Standard errors	(1) ±1.22, (2) ±1.72.							
	TOPS: tons per acre (±0.476)				SUGAR PERCENTAGE			
No nitrate of soda ..	9.64	10.78	14.12	14.32	16.20	16.41	16.08	16.44
Nitrate of soda ..	10.08	12.38	13.78	15.58	15.94	16.20	16.34	16.27
Early	10.07	12.46	14.70	16.81	16.42	17.01	16.78	16.90
Late	9.65	10.70	13.20	13.10	15.72	15.60	15.64	15.81
Mean	*9.86*[1]	*11.58*[1]	*13.95*[1]	*14.95*[1]	*16.07*	*16.30*	*16.21*	*16.36*
Increase		*+1.72*[2]	*+2.37*[2]	*+1.00*[2]		*+0.23*	*−0.09*	*+0.15*
Standard errors	(1) ±0.337, (2) ±0.476							
	PLANT NUMBER: thous. per acre							
No nitrate of soda ..	28.2	29.2	28.0	32.0				
Nitrate of soda ..	29.2	29.8	29.3	28.0				
Early	30.4	30.5	30.0	30.8				
Late	27.0	28.4	27.4	29.2				
Mean	*28.7*	*29.5*	*28.7*	*30.0*				
Increase		*+0.8*	*−0.8*	*+1.3*				

Conclusions

Mixed artificials produced significant increases in both total sugar and tops. The response fell off significantly at the higher levels of application with sugar, there being no further response after 8 cwt. per acre. With tops, however, there was little indication of a falling off in response.

The responses to mixed artificials were somewhat greater with early lifting (Nov. 5 and 6) than with late lifting (Dec. 17), the difference being definitely significant in the tops, though not significant in sugar.

The yield of sugar was decreased by 1.7 cwt. per acre and that of tops by 1.8 tons per acre at the later lifting, the decrease being significant in tops but not in sugar.

The response to nitrate of soda was significant in tops but not in sugar.

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Sugar Beet. W. R. Smith, Esq., Holton-le-Moor, 1937
Brigg Beet Sugar Factory

4×4 Latin square. Plots : 1/40 acre.

TREATMENTS : Singled to exactly 11 inches (A), selection of strongest plant within 3 inches of exact distance (11 inches) (B), selection of weakest plant within 3 inches of exact distance (11 inches) (C), singled to 11 inches seven days later (D).

BASAL MANURING : 8 cwt. compound fertiliser and 10 loads of dung.

SOIL : Sand. Variety : Kleinwanzleben E. Seed sown : May 24. Singled : June 12 and 19. Lifted : Oct. 20 and 21. Previous crop : Barley.

STANDARD ERRORS PER PLOT : Total sugar : 1.40 cwt. per acre or 3.26%. Tops : 0.789 tons per acre or 5.07%. Mean dirt tare : 0.086.

	TOTAL SUGAR		ROOTS (washed)		TOPS		SUGAR PERCENTAGE		PLANT NUMBER	
	Cwt.	*Increase*	Tons	*Increase*	Tons	*Increase*		*Increase*	Thous.	*Increase*
Mean	*43.0*		*12.17*		*15.55*		*17.69*		*27.8*	
A	44.0		12.39		15.37		17.74		28.6	
B	44.3	*+0.3*	12.53	*+0.14*	15.50	*+0.13*	17.69	*−0.05*	28.8	*+0.2*
C	41.8	*−2.2*	11.92	*−0.47*	15.90	*+0.53*	17.54	*−0.20*	27.2	*−1.4*
D	42.1	*−1.9*	11.84	*−0.55*	15.42	*+0.05*	17.78	*+0.04*	26.7	*−1.9*
St. errors	±0.700	*±0.990*			±0.394	*±0.557*				

Conclusions

The effects of the different methods of singling on the yields of sugar per acre and on tops were not significantly different. It may be noted, however, that as in the 1936 experiments, the selection of the weakest plants gave the lowest yield of sugar.

Sugar Beet. J. W. Auckland, Esq., Thornton, 1937
Bardney Beet Sugar Factory

4×4 Latin square. Plots : 1/80 acre.

TREATMENTS : Singled to exactly 11 inches (A), selection of strongest plant within 3 inches of exact distance (11 inches) (B), selection of weakest plant, within 3 inches of exact distance (11 inches) (C), singled to 11 inches seven days later (D).

BASAL MANURING : 10 cwt. compound fertiliser per acre, and 10 loads of dung.

SOIL : Sand. Variety : Dippe E. Seed sown : May 10. Singled : June 8 and 15. Lifted : Nov. 4. Previous crop : Barley.

STANDARD ERRORS PER PLOT : Total sugar : 2.21 cwt. per acre or 4.00 %. Tops : 1.04 tons per acre or 10.7%. Mean dirt tare : 0.138.

	TOTAL SUGAR		ROOTS (washed)		TOPS		SUGAR PERCENTAGE		PLANT NUMBER	
	Cwt.	*Increase*	Tons	*Increase*	Tons	*Increase*		*Increase*	Thous.	*Increase*
Mean	*55.2*		*14.99*		*9.68*		*18.41*		*27.2*	
A	56.6		15.25		9.35		18.55		26.9	
B	57.3	*+0.7*	15.60	*+0.35*	9.95	*+0.60*	18.38	*−0.17*	27.4	*+0.5*
C	53.9	*−2.7*	14.55	*−0.70*	10.02	*+0.67*	18.52	*−0.03*	29.1	*+2.2*
D	52.9	*−3.7*	14.55	*−0.70*	9.42	*+0.07*	18.18	*−0.37*	25.2	*−1.7*
St. errors	±1.10	*±1.56*			±0.520	*±0.735*				

Conclusions

The differences in yield of total sugar produced by the different methods of singling were not significant. There is, however, some indication that the selection of the weakest plant reduced the yield, while late singling also gave a reduced yield.

There were no significant differences in the yields of tops.

Sugar Beet. C. J. Neale, Esq., Newark, Kneeton, Notts., 1937
Kelham Beet Sugar Factory

4 randomised blocks of 12 plots each. Plots: 0.01613 acre.

TREATMENTS: 4 × 3 factorial design.

Nitrogen: None, cyanamide, nitrochalk and sulphate of ammonia at the rate of 0.6 cwt. N per acre.

Phosphate: None, superphosphate and slag at the rate of 1.0 cwt. P_2O_5 per acre.

BASAL MANURING: Muriate of potash at the rate of 1.0 cwt. K_2O per acre.

SOIL: Light loam. Variety: Kleinwanzleben E. Manures applied: April 7. Seed sown: May 19. Lifted: Dec. 11. Previous crop: Wheat.

STANDARD ERROR PER PLOT: Total sugar: 3.76 cwt. per acre or 11.8%. Mean dirt tare: 0.390.

	None	Cyanamide	Nitrochalk	Sulph. amm.	*Mean* (*±0.940*)	*Increase* (*±1.33*)
	TOTAL SUGAR: cwt. per acre (±1.88)					
None ..	29.0	28.4	34.8	30.9	*30.8*	
Super. ..	29.8	31.5	36.4	36.9	*33.6*	*+2.8*
Slag ..	23.8	33.0	34.2	33.5	*31.1*	*+0.3*
Mean (*±1.09*)	*27.5*	*31.0*	*35.1*	*33.8*	*31.8*	
Increase (*±1.54*)		*+3.5*	*+7.6*	*+6.3*		
	ROOTS (washed): tons per acre					
None ..	9.24	9.09	11.01	9.89	*9.81*	
Super. ..	9.53	10.08	11.64	11.60	*10.71*	*+0.90*
Slag ..	7.60	10.26	10.80	10.79	*9.86*	*+0.05*
Mean ..	*8.79*	*9.81*	*11.15*	*10.76*	*10.13*	
Increase ..		*+1.02*	*+2.36*	*+1.97*		
	SUGAR PERCENTAGE					
None ..	15.68	15.60	15.80	15.58	*15.66*	
Super. ..	15.62	15.62	15.65	15.90	*15.70*	*+0.04*
Slag ..	15.62	16.08	15.82	14.48	*15.50*	*−0.16*
Mean ..	*15.64*	*15.77*	*15.76*	*15.32*	*15.62*	
Increase ..		*+0.13*	*+0.12*	*−0.32*		
	PLANT NUMBER: thousands per acre					
None ..	33.5	32.1	32.6	32.9	*32.8*	
Super. ..	32.9	33.7	32.1	33.8	*33.1*	*+0.3*
Slag ..	30.1	33.7	31.1	32.0	*31.7*	*−1.1*
Mean ..	*32.2*	*33.2*	*31.9*	*32.9*	*32.5*	
Increase ..		*+1.0*	*−0.3*	*+0.7*		

Conclusions

There were significant responses in total sugar to all three forms of nitrogenous fertilizer. The responses to nitrochalk and sulphate of ammonia were not significantly different, but the response to cyanamide was significantly less than that to nitrochalk and somewhat less than that to sulphate of ammonia. There are also indications of a positive interaction between the effects of nitrogen and phosphate, though this was not significant.

The average response to superphosphate was just significant at the five per cent. level. In the absence of nitrogen, slag produced an apparent depression of yield, which was, however, not significant. In presence of nitrogen, slag produced a small but not significant increase in yield.

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Kale. Midland Agricultural College, Loughborough, 1937

4 randomised blocks of 6 plots each. Plots: 1/40 acre.

TREATMENTS: 3×2 factorial design.
Nitrate of soda: None, 2 and 4 cwt. per acre as top dressing. Unthinned and thinned.

BASAL MANURING: 15 tons farmyard manure, 8 cwt. slag, 2 cwt. 30% potash salt, 1 cwt. nitrate of soda.

SOIL: Light loam. Variety: Marrowstem. Seed sown: April 26-27. Nitrate of soda applied: May 20-25. Harvested: Oct. 26-Nov. 4. Previous crop: Wheat.

SPECIAL NOTE: The thinned plants were 6 inches apart.

STANDARD ERROR PER PLOT: 2.49 tons per acre or 10.5%.

Tons per acre (±1.24)	Nitrate of Soda (cwt.) None	2	4	*Mean* (*±0.716*)	*Increase* (*±1.01*)
Unthinned	23.69	24.19	24.56	*24.15*	
Thinned	21.56	23.94	24.44	*23.31*	*−0.84*
Mean (*±0.877*)	*22.62*	*24.06*	*24.50*	*23.73*	
Increase (*±1.24*)		*+1.44*	*+0.44*		

Conclusions

The increase in yield due to nitrate of soda and the slight decrease due to thinning were not significant, though they agree in direction with the results found in previous years.

ABBREVIATED LIST OF THE FIELD EXPERIMENTS

Experiments at Outside Centres

Experiments carried out by Local Workers

Note.—N denotes sulphate of ammonia or nitrate of soda, P denotes superphosphate, and K denotes any potash fertiliser.

ERRATA

1932 Report

p. 203. Salt was applied at the rate of 0.85 cwt. Cl. per acre.

1936 Report

p. 204. The third sentence from the foot of the page should read " The response to each was somewhat greater at the lower level of the other than at the higher level, but the difference was not significant."

p. 223. In harvesting the kale, two guard rows were omitted from each plot. All yields and their standard errors should be multiplied by 18/16 or 1.125.

p. 233, line 4 in the table. For " Blakewell " read " Bakewell."

p. 272, line 3. For " 3 x 2 factorial design " read " 3^2 factorial design."

Lawes Agricultural Trust

JANUARY—DECEMBER, 1937

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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