ROTHAMSTED RESEARCH

Report for 1972 - Part 1

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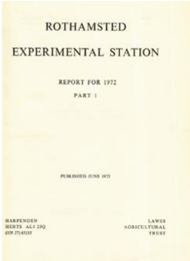
ROTHAMSTED
EXPERIMENTAL STATION
REPORT FOR 1972
PART 1

Computer Department

D. H. Rees

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COMPUTER DEPARTMENT

D. H. REES

The Computer Department provides a centralised computing service to institutes of the Agricultural Research Service in England and Wales. Of the two computers in operation at the beginning of the year, one, the ICL Orion, was closed down in March after eight years service. The service is now based on the ICL 4–70 using the Multijob operating system. There has been an encouraging improvement in overall system reliability since the introduction of Multijob version M750, leading to a marked increase in work throughput, particularly noticeable after the addition of the extra core and new high speed drums.

Computers

Orion. This machine was closed down on 30 March 1972. It was dismantled by the maintenance staff and many of the sub-units and components were made available to other departments of Rothamsted and other institutes' staff.

Performance. Instead of reviewing the three months performance data, the records, which have been published in Annual Reports since 1964, have been combined into a single set of Tables 1 and 2.

TABLE 1

Orion performance 1964–72 (total hours worked)

	Maintained (hours)	Unmaintained (hours)	Total (hours)	% (total)
Productive	12681	4416	17097	88
Unproductive				
Failures	1869	139	2008	10
Restarts	379	70	449	2
	14929	4625	19554	100

The Orion was available for 19 554 hours (Table 1) and of this 88% was directly productive, 10% was lost through faults and engineering repairs and 2% to restoring the system and repeating any spoilt work. Maintenance engineers were on site for only 78% of the time—and 26% (4416 hours) of the total useful work (17 097 hours) was completed during the unmaintained period. This was possible because, of the total lost time (2008 hours), only 7% occurred during the unmaintained period. Fortunately, most failures requiring engineering attention took place shortly after the Orion was switched on in the morning; other fault conditions tended to be transient. Failures were frequent and the longest period without any recorded fault was four consecutive working days and this occurred only once during the eight years Orion service. The Orion was too complex a system for the available manufacturing techniques and there was insufficient development by the company to rectify basic problems.

Despite this, a number of important new computing techniques were successfully implemented on it. Of these, multiprogramming was most important. This is a method whereby all the resources of the system are shared between several independent jobs with each job receiving its share of the central processor's attention as required. New hardware

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and systems software concepts were necessary and about 6% of the system resources were required as an overhead cost for this facility. However, multiprogramming allowed between two and three jobs to be loaded and to be processed in the machine at any one time.

Multiprogramming raised new problems about measuring and costing jobs. The elapsed time of jobs was no longer a meaningful index. So a novel accounting procedure was devised which took account of the duration of the various resources used, weighted by cost factors. The factors chosen were those known to have been in use at a commercial Orion bureau in 1964 and therefore nominally corresponded to a commercial computing charge. The distribution of the computing effort between the various institutes was measured in this way, and the totals for the period are given in Table 2. For consistency

TABLE 2

Orion—distribution of work 1964–72 (percentage total nominal value £000)

		%
Rothamsted		
Development	19·5	
Production	24·2	
		43·7
Other Institutes		
Development	9·7	
Production	22·1	
		31·8
Experiments		21·2
Systems		3·3
		100·0
Total work (£000)		2142·0

the cost factors were unchanged during the life of the Orion and this has produced a total charge of £2·142 M. Bureau costs were not stable during the whole period and the 'true' cost is probably closer to £1·3 M. This was still in excess of the capital, overheads and running costs of the Orion service, thus demonstrating the cost effectiveness of an 'in-house' service.

It is interesting to note in Table 2 that Rothamsted development (19·5%) was twice that of all other institutes (9·7%) whilst the non-experimental production costs were similar. Development here includes testing jobs as well as programs and both required the rapid turnround of work. Users at other institutes were at a disadvantage despite the late introduction of Telex. This handicap was noted early in the Orion service and indicated the prime need for direct user access to any future central computer facility. This is now available on the ICL 4–70.

The Orion was almost exclusively used in statistical computing and 21·2% was taken up with the analysis of replicated experiments. A total of 46 791 experiments were processed and 357 353 variates analysed at an average of 7·6 variates per experiment. This ratio steadily increased from 5·3 in 1964 to 8·8 in 1971. The analysis of survey data also accounted for much of the general production work at Rothamsted.

The Orion, the third computer at Rothamsted, was an important step in the development of computing in the Agricultural Research Service. It established the power of the computer for investigatory and routine statistical procedures and confirmed that a centralised computing service could be operated from Rothamsted. The major requirements of the replacement computer were identified as a consequence of the Orion operating experience. One disappointment was the failure of the company to exploit the potential of the Orion concept but it has left a mark which can be seen even on the newest range of British computers.

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4–70. An 85-hour two-shift week—less four hours for routine maintenance—was set up in January. The last company release of Multijob—M750—was put into service in February. Additional core store, drums, replaceable disc drives (RDS) and communication buffers were added from September onwards. The system configuration at the end of the year was as follows:

448	Kbytes core store	(K=1024)
2	2·2 Mbytes drums	
10	7·25 Mbytes RDS	
4	60 Kbytes/sec magnetic tape drives	
2	line printers, 2 paper tape readers, 1 card reader, 1 paper tape punch	
34	110 character per second (cps) teletype buffers	
3	600/1200 cps video buffers	
2	2400 cps buffers	

Performance. The performance data is given in Table 3. Before reviewing this, a brief account of the background of the data is necessary.

The working day is divided into three sessions:

07.30–10.00 for housekeeping and systems work
10.00–18.00 for multiaccess
18.00–00.30 for large batch

Housekeeping means those essential services which maintain the system in good working order. Systems work refers to work done on Multijob to correct errors, to modify or even add extra facilities. Multiaccess is that mode of operation when users with teletypes have direct access to the computer. Large batch is that mode of operation which maximises the amount of core store for jobs and is made available by removing the multiaccess facility.

The job unit is not generally equivalent to a user job. Under Multijob, user jobs can be batched as a single job or executed as a sequence of sub-jobs; it is to either of these

TABLE 3

4–70 Performance (percentage total operational hours)

	1 Jan.–3 Nov.	4 Nov.–31 Dec.		Overall
Total operations (TO)	3867 hours	607 hours		4474 hours
As percentage of (TO)				
productive time	%	%		%
Multiaccess	46·2		44·3	46·0
Large Batch		35·8		
Housekeeping	44·9	10·3	48·2	45·3
Systems		2·1		
Unproductive time				
Failures (all causes)	3·6		1·5	3·3
Routine maintenance	4·5		5·6	4·6
Unaccounted time	0·8		0·4	0·8
Total	100·0		100·0	100·0
Total working days (WD)	214·5		37·0	251·5
(TO)/(WD)	18·0		16·4	17·8
Total 'Jobs' (J)	98449		24247	122696
(J)/(WD)	459		655	488
Productive time/(J)—minutes	2·15		1·39	2·00
Total system failures (SF)—all causes	574		39	613
Failure time/(SF)—minutes	14·5		13·8	14·5
(SF)/(WD)	2·7		1·1	2·4

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that the table refers. Information concerning jobs is recorded in various system journals and these journals are processed on the 4–70 to provide the summary given in Table 4.

Returning to Table 3—as well as the annual summary, the year is divided into two periods in order to demonstrate the improved throughput due to the additional equipment coupled with a more reliable system. The classification of work into housekeeping, systems and large batch was only recorded for the latter months and are included here as an indication of their relative proportions.

The lost time due to failures decreased from 3·6 to 1·5% and this was consistent with the marked reduction in the number of daily failures, from 2·7 to 1·1. There was little change in the lost time per incident—14·5 minutes to 13·8 minutes. These all point to a more reliable central system—a fact of great encouragement to users and the operations staff. (Gledhill, Baylis, Guthrie and Coles)

The number of jobs per working day increased by 40% from 459 to 655. This was achieved with a decrease in the average daily number of working hours from 18·0 hours (including overtime) to 16·4 hours (barely two shifts). Assuming that the characteristics of the work load has not changed—this increase in throughput is mainly attributable to the additional equipment. Put another way the 40% improvement was a direct benefit of a 20% increase in the capital value of the computer.

Every incident disrupted the continuity of the system journals and led to an inconsistency between the total time given by these journals and the external clock time. This is shown as 'unaccounted time' in Table 3. For the same reason the number of jobs shown is less than the true value.

As with the Orion, measuring throughput by job count is not an accurate method and a process analogous to the Orion costing program has been developed. For reasons concerned with the design of Multijob, it is not as sensitive as the Orion version and further work has yet to be carried out on this problem. For the present, accounting is done in elapsed time units (ETU's) and not in 'cash' units. The distribution of these costs over the institutes from 1 April 1972, together with the job unit count, is given in Table 4.

TABLE 4

Distribution of work by Institutes for the period 1.4.72–31.12.72 (percentage jobs and ETUs)

		ETUs 866486 %		Jobs 81524 %	ETU/job
Rothamsted Experimental Station					
Systems	10·8		13·0		8·9
Computer Department	11·1		13·4		8·8
Statistics Department	25·8		18·3		14·9
Others	6·2		3·6		18·1
		53·9		48·3	
National Vegetable Research Station		13·3		15·0	9·4
National Institute of Agricultural Engineering		12·7		14·3	9·5
Grassland Research Institute		6·6		4·3	16·5
East Malling Research Station		4·5		7·1	6·7
Glasshouse Crops Research Institute		1·8		2·2	8·7
Letcombe Laboratory		1·8		2·1	9·0
National Institute for Research in Dairying		1·6		2·2	7·7
National Institute for Agricultural Botany		1·5		1·3	12·7
Others (< 1%)		2·3		3·2	7·4
		100·0		100·0	

Data derived from such tables will be used to assign computing service project costs amongst the institutes. In due course it will be possible to charge computing against an individual project. The ratio of ETU's/job is shown as a crude index of the job profile of institutes.

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Returning to Table 3 although the indications are favourable, the true performance, as experienced by the individual user, is less satisfactory. For example, most of the failure incidents took place during the multiaccess session, a time of great inconvenience to users and the operators. It is entirely a matter of chance whether a user could restart his work at the point of system failure or must make a fresh start. Another vexatious source of trouble was the small margin of disc storage available for temporary working space. Here system failures or even users' mistakes caused files or even jobs to be lost. Incidents of this kind are not adequately recorded in the journals and it is impractical at this stage to attempt to reconcile these events with a view recovering a true measure of user satisfaction. Indeed the selection and presentation of data suitable for management and costing purposes is still being investigated. (Rees, Gledhill and Gardner)

Time division multiplexing. Initially teletypes could only be connected to the 4–70 either through the normal dial-up service or by private circuits. As the demand for more teletypes grew at the institutes it was shown to be more effective to hire a single high speed private circuit and to use suitable equipment to pack (and unpack) the independent inputs into a form suitable for transmission down the single high speed circuit. This is the time division multiplexing (TDM) technique and equipment has now been installed at National Vegetable Research Station for four teletypes; National Institute of Agricultural Engineering for four teletypes; Grassland Research Institute for three teletypes and East Malling Research Station for two teletypes, and brings to 34 the total number of simultaneous teletype connections to the 4–70. The TDM technique will, in due course, also permit faster devices such as fast serial printers, video display units, to be used at the institutes. (Martin and Moore)

Job reception. Although much work is handled through the communication network a significant share of the input comes to the Department directly as cards or paper tapes: the line printer output has also to be distributed to users. About 100 items of work are handled in this way daily—three-quarters from Rothamsted: all the line printer output has to be sorted, packaged and posted. Postal costs are roughly 50% up on last year despite a more careful scrutiny of optimum parcel weights. An investigation into the first-class delivery service failed to confirm the Post Office's target figures. It also revealed the anomaly that some institutes were better served by the late afternoon collection rather than by the noon collection.

Programming

There is a wide range of programming activities within the Department. They include work on systems, utilities, scientific and application packages, sponsored requests and telecommunications.

Systems. Since the introduction of M750 the software operations environment has become more stable and has given the systems programmers confidence to investigate and modify the Multijob operating system. Regretfully, there is still a paucity of reliable Multijob documentation and progress is all the slower for this. Some of these changes affect the users' view of the system and must therefore be carried forward into future releases of which three have been forecast by the company. These are M800—due in April 1973; M900—due early in 1974 and M1000—due in the third quarter of 1974. More fundamental changes to Multijob are being examined and specifications drafted with the aim of providing better facilities for the users. Technical details of all changes are published in various departmental documents and will not be repeated in this Report. (Gledhill, Guthrie, Sharma, Tan and Thomson)

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Utilities. These are programs of general value and are used either alone or as parts of a larger user program. Some of these programs are created by departmental staff—others are taken from outside sources and made to work under Multijob. All these programs are verified before the user documentation is released. Some examples of utilities are; the ICL Sort-Merge Package for sorting and merging files which is an essential facility for updating large files. (Beasley and Christine Shelley) However, the ICL program for the maintenance of magnetic tape files had limited facilities so a new set of programs for handling such files more effectively and conveniently has been prepared. (Clarke) The Fortran Plotting Package was released this year (Thomson) but further work has been done to make this more accessible to Fortran and CSMP (Continuous System Modelling Program) users. (Beasley, Bicknell, Christine Shelley and Thomson) Comprehensive routines for producing graphical output on teletypes and line printers were also produced. (Yates and Woodford) A program is available as an aid to Fortran programmers interested in improving the efficiency of their programs. (Clarke)

Scientific and application programs. Work on the scientific program library continues but with greater reliance on outside sources than had been expected. The universities have set up a project for creating a library of proven scientific routines using trusted algorithms. Rothamsted intends to benefit from this and will collaborate with others in setting up this library in Multijob. (Beasley)

Work on application packages continues and the main lines of interest are briefly reviewed here.

CSMP. This package has been available to users since 1971. Not enough attention was paid to the operational aspects of this first version, and there was some user dissatisfaction with it. This was due to the clumsy internal organisation of the program, a direct consequence of Multijob. There has been a major review of CSMP leading to important operational improvements which are currently under test. (Bicknell) In addition to this, new features have been added including the display of results on the plotter as well as the selection of output for printing on teletypes. (Bicknell) There is widespread interest in this technique and already a number of models have been simulated ranging from the behaviour of parasites to the mechanical stability of farm equipment. The department has been able to provide advice and assistance in setting up these programs under CSMP. (Jackson) This is not the only way of studying models; and more work is required to establish the importance of this technique to agricultural research workers. The responsibility of this department is to provide the programming tools and the opportunities for using them—the justification of the method rests with the users.

SYMAP. The interface with GENSTAT was completed and is in operational use. This allows users to display data in a map format. (Clarke)

Fitcon and Fitquan. The interface with the General Survey Program (GSP was completed and is in use. This allows the 'fitting constants' technique to be applied to data derived from surveys. (Clarke)

LP400. This, rather large, ICL general linear programming package is still under test. (Clarke)

DESCAL. An on-line ICL calculator facility was tested and found to contain several errors—some catastrophic in their consequences. These have been corrected and documentation has been circulated. (Beasley and Beryl Hersom)

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BASIC. This is a general purpose programming language—somewhat easier to use than Fortran for small problems. There are many good manuals and tutorial books available. Documentation has been prepared and circulated. (Beasley, Christine Lessells and Beryl Hersom)

GSP. Part One of the General Survey Program is completed and has been used successfully on a number of Surveys including:

Soil Survey data for the Survey of Fertiliser Practice (SFP) 1969, 1970 and 1972
Cereal Foliar Disease Survey and a Pesticide Survey (MAFF)
Survey on Wild Oats and Blackgrass (WRO)
Other institutes are using GSP under their own auspices.

Good progress is being made with Part Two including a draft Users' Guide, as well as linking Parts One and Two. (Yates, Christine Lessells and Woodford)

Sponsored programs. The department does not provide a service for individual problems. It will assist in setting up programs of general value and will offer detailed programming effort for work which has a significant system element in it.

As an example, and at the request of the Field Experiments Section—a program to produce the randomised layout of field experiments plots, which had been written by H. D. Patterson (ARC Unit of Statistics, Edinburgh) for an IBM 1130, was translated to run on the 4–70. (Gardner)

Other examples were:

The input and editing of paper tape records for the Cereal Foliar Disease Survey. (Sharma)

The input, editing and organisation of data logged tapes, from the Physics Department. (Beryl Hersom)

The preparation and maintenance of Mass Spectral records for FRI. (Clarke)

Text translation program for Soil Survey. (Christine Lessells)

The routine analysis of output tapes from automatic amino acid analysers. (Bicknell)

New programming languages. FORTRAN is the staple programming language on the 4–70. Its virtues to users are that it is widely available with a good supply of tutorial manuals and reasonable access to training courses. However, because it appeared early in the history of computing it lacks many features which are now recognised as desirable for the wider range of programming problems now being encountered. For example it is not an easy language to use where interactive computing is required. BASIC is a more convenient language for the less experienced user with simple problems. FORTRAN is not suitable for desk calculator type computation; DESCAL, with all its limitations, is more appropriate. However, looking ahead, the need for new programming facilities is recognised and a number of new languages are being assessed; any new language must have a well-defined interface with FORTRAN and this may eventually limit the choice. (Bicknell and Clarke)

Telecommunications. Program modifications have been made to the EAL DCT 132 terminal linked to the Edinburgh Regional Computing Centre (ERCC). These include an error counting routine for the Post Office Dial-Up 2400 band experiment, paper tape reading routines and routines for handling a teletype input. These are preliminary preparations for the future use of this equipment as a high speed terminal on the 4–70. (Moore)

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Communications

Developments this year include the installation of an auto answering set for the dial-up users; the commissioning of the time division multiplexing equipment, the evaluation, on behalf of the Post Office, of the prototype Dial-Up 2400 band Datel Service and the specification and assessment of equipment for the front end processor project. (Martin and Moore)

Other Services

Advisory. There are two types of service offered by the Department—those dealing with FORTRAN and Application Programming problems (Clarke, Beryl Hersom, Jackson, Christine Lessells and Christine Shelley, Thomson and Woodford)—the others with operational and systems queries. (Gledhill, Baylis, Coles and Gardner)

Courses. There were eight two-day courses on the advanced uses of Multijob held at outside institutes and two two-day introductory courses at Rothamsted. More than 150 people attended all courses. (Gledhill, Coles, Clark and Christine Shelley)

Punching. About 950 000 cards were handled and there was a noticeable increase in the amount of paper tape work. An investigation was made into first-class postal services which did not confirm the P.O.'s claims. (Fearne)

Publications. Four Newsletters and 90 technical documents were prepared and circulated to users. (Fearne and Cora Cottrell)

User groups. The main user group met twice during the year. Professor C. Pearce (East Malling Research Station) is now chairman of this group. Three working parties have been set up on specialised topics.

Staff

I. L. Barrett, S. F. Chilton, S. S. Dhir, B. R. Dodia, R. P. Hickling, R. J. Higgins, Virginia Kemp, H. Taylor, Patsy Withers were appointed. A. P. Gardner joined the department as a one-year sandwich course student replacing Monica Raddan. The following staff resigned: Avril Beckett, Carole Belcher, Janice Bending, D. Cockburn, S. J. Coles, M. D. Cox, Karen Hopkins, C. H. Hurford, Geraldine Impey, Maisie Sheed, Christine Smith, M. D. Sutton, D. Teather and D. J. Wilson.

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FIELD EXPERIMENTS SECTION

G. V. DYKE

Field Plots Committee

The field experiments at Rothamsted, Woburn and Saxmundham are controlled by the Field Plots Committee: G. W. Cooke (Chairman), G. V. Dyke (Secretary), J. McEwen (Deputy Secretary), J. M. Hirst, A. E. Johnston, F. G. W. Jones, J. R. Moffatt, R. Moffitt, J. A. Nelder and C. P. Whittingham.

F. C. Bawden, who died in February 1972, had served on the Committee since 1954. He was the first Chairman of the Working Party for Pathology Experiments but remained an ordinary member of the main Committee.

TABLE 1

Number of plots in 1972

	Grain	Roots	Hay	Total
Full scale plots (yields taken):				
Classical experiments:				
Rothamsted	518	35	208	761
Saxmundham	—	—	80	80
Long-period rotation experiments:				
Rothamsted	772	200	76	1048
Woburn	218	484	32	734
Crop-sequence experiments:				
Rothamsted	1022	118	104	1244
Woburn	443	523	20	986
Saxmundham	136	—	—	136
Annual experiments:				
Rothamsted	1058	578	—	1636
Woburn	168	232	—	400
Saxmundham	48	—	—	48
Totals:				
Rothamsted	3370	931	388	4689
Woburn	829	1239	52	2120
Saxmundham	184	—	80	264
Total	4383	2170	520	7073
Full scale plots (no yields taken):				
Rothamsted				563
Woburn				277
Microplots:				
Rothamsted				1417
Woburn				425
Saxmundham				220
			Total	9975

Table 1 shows the number of plots on the three farms; the total is about 500 less than in 1971. Plots in crop-sequence experiments continued to increase in number but there were less in annual experiments; this reflects our increasing concern with residual effects, whether of applied chemicals or of contrasted cropping. In 1972 there were more plots of root crops at Woburn than at Rothamsted. The number of microplots, which fluctuates relatively more than the number of full-scale plots, was about 2000 in contrast to the 3100 in 1971.

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The Committee held six formal meetings during the year and its main working parties a total of nine meetings; also many informal meetings and tours of experiments. Most of these meetings involved lively discussion between members of different departments.

Experimental designs by computer. A program written by Mr. H. D. Patterson and Mrs. J. A. Tolmie (ARC Unit of Statistics, Edinburgh), now running on the Rothamsted computer, prints all designs for our experiments. This program designs simple and factorial experiments (with confounding or fractional replication) laid out in randomised blocks, Latin or Lattice Squares and 'restriction' of randomisations is an option available in certain types of design.

The output can be varied to suit individual requirements; treatment names can be short and symbolic ('N1P1K1', etc) or longer and self evident (names of not more than 16 alphabetic or other characters).

The boundaries of plots, etc., are indicated by lines of numerical characters, different ones being used for boundaries of sub-plots, whole-plots, blocks, etc.

This program is markedly better than the Orion program used previously (*Rothamsted Report for 1969*, Part 1, 281).

Visitors. The total number of visitors to the Station during 1972 (but excluding the many individuals who visited individual members of the staff) was about 3000, as in recent years. Of these about 500 came from overseas, including 13 organised groups. Visits by overseas groups, especially of university or technical students have increased lately and we expect a continued increase now that Britain is a member of the EEC. More groups come outside the summer season now and we increasingly need a well-equipped lecture theatre to allow appropriate lectures and demonstrations. We begin to need demonstrators reasonably fluent in the languages of Western Europe.

Small-plot experiments

The Section undertook all agricultural operations on 26 experiments, involving 1022 plots, and some operations on 20 others.

A Claas 'Compact 20' combine harvester was bought just before harvest. Grain from small plots of cereals is intercepted before it reaches the elevator and is delivered into a plastic tray which is readily removed and emptied into a sack. The cutting width is 1·72 m, which suits plots sown with the 'Fiona' drill.

The combine seems to work well on wheat and barley but at present is not suitable for small plots of beans as grain accumulates on the table.

We believe that wheelmarks made during spraying should not, in general, fall within the sown area of plots, especially if much sampling of the crop is planned. The small sprayer, working from narrow side-paths, achieves this in most of our cereal experiments; we are now planning to modify some potato experiments by leaving paths equivalent to one row in width (70 cm) at suitable intervals. (Wilson, Turnell and McKenzie)

Annual summary of yields from standard experiments at Rothamsted and Woburn

Winter wheat. On Broadbalk yields of wheat, variety Cappelle, after beans and after fallow were mostly 0·5–1 tonne/ha better than in 1971 and more than 1 tonne better than in 1970 (Table 2). Continuous wheat since 1952, by contrast, yielded a little less in 1972 than in 1971. In 1972 FYM alone again gave more wheat than did fertilisers; after beans FYM gave our first Broadbalk yield of 8 tonnes/ha (64 cwt/acre). 'Nitro-Chalk' at 96 kg N/ha gave more wheat than heavier applications although there was no lodging.

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TABLE 2

Broadbalk Wheat; yields of crops from selected treatments

Grain, tonnes/ha

	1972			1971			1970		
Treatment	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
None	3·4	3·1	1·6	2·5	3·1	2·1	2·3	3·0	2·1
N2	5·8	3·6	3·2	5·4	4·1	3·3	4·4	4·3	1·9
PKNaMg	4·2	4·0	2·1	2·6	3·8	2·5	2·5	4·0	2·6
N1PKNaMg	6·2	5·6	4·7	4·9	4·7	4·5	4·6	4·5	4·1
N2PKNaMg	6·6	6·4	5·3	6·4	5·1	6·0	5·3	4·6	5·1
N3PKNaMg	6·5	5·6	5·0	6·0	5·3	5·7	4·9	4·8	5·8
N4PKNaMg	6·0	6·0	5·1	6·0	5·4	5·3	5·1	4·6	5·5
N2P	6·6	5·2	4·1	5·1	3·0	4·2	4·5	3·8	3·6
D	8·0	7·6	6·3	6·9	7·3	6·5	5·9	6·3	5·3
DN2	6·9	6·9	3·8	4·9*	6·1	4·9*	5·6	5·8	4·5
R	6·2	7·0	4·6	5·7	5·2	4·6	4·9	4·6	3·6
Mean of all plots	6·3	5·7	4·6	5·5	5·0	4·9	5·0	4·6	4·3

(a) Wheat after potatoes, beans
(b) First wheat after fallow
(c) Continuous wheat since 1952

Symbols: N1, N2, N3, N4 = 'Nitro-Chalk' at 48, 96, 144, 192 kg N/ha
P = Superphosphate annually, at 73 kg P_2O_5/ha
K = Sulphate of potash annually, at 110 kg K_2O/ha
Na = Sulphate of soda annually, at 16 kg Na/ha
Mg = Sulphate of magnesia annually, at 11 kg Mg/ha
D = Farmyard manure annually, at 35 tonnes/ha
R = Castor meal annually, at 96 kg N/ha

*Badly lodged

On the Rothamsted Ley–Arable wheat did not appear in 1972 as second test-crop (first cereal) after the treatment crops; we have yields of wheat as third to sixth cereal but all these crops suffered the effects of take-all to various degrees. Such yields seem less relevant to the present summary and are omitted.

Joss Cambier was grown on many experiments in 1972 but, for the first time on our farm, it suffered moderate to severe attacks of yellow rust (*Puccinia striiformis*). Some of the yields of this variety discussed below were undoubtedly decreased by rust though we have no measure of the effect.

On the plots of the former Intensive Spring Barley experiment, for example, yields were less than in 1971 (though better than in 1970—Table 3).

TABLE 3

Winter Wheat after Intensive Spring Barley experiment

Wheat (Joss Cambier), grain, tonnes/ha
(Continuous wheat since 1961, spring-sown 1961–68)

1972	1971	1970
126 kg N/ha	126 kg N/ha	126 kg N/ha
4·8	6·0	4·0

Basal dressing: 35 kg P_2O_5, 70 kg K_2O/ha (1972, 1971)
157 kg P_2O_5, 314 kg K_2O/ha (1970)

Cappelle (which did not suffer appreciably from rust) on the Cultivation/Weedkiller Rotation experiment yielded about 1 tonne more per hectare than in 1970 (Table 4); spring wheat was grown in 1971 and yielded relatively poorly.

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TABLE 4

Cultivation-Weedkiller Rotation experiment

Wheat (Cappelle), grain, tonnes/ha

	1972	1971	1970
Ploughed	7·1	4·2*	5·6
Rotary cultivated	6·6	4·2*	5·5
Tine cultivated	6·4	4·0*	5·7

Basal dressing: 25 kg N, 60 kg P_2O_5, 60 kg K_2O at sowing, plus 79 kg N/ha in spring (1972)
90 kg N, 38 kg P_2O_5, 38 kg K_2O/ha (1971)
19 kg N, 47 kg P_2O_5, 38 kg K_2O at sowing, plus 79 kg N/ha in spring (1970)

* Spring wheat (Kolibri)

At Woburn, Cappelle grown on the Intensive Cereals experiment gave maximum yields of 3·8 tonnes/ha in rotation, 2·6 in continuous wheat (Table 5). These yields are 1·2 tonnes less than in 1971, and roughly equal to those of 1970.

Winter wheat was grown on the Woburn Ley–Arable experiment in 1972 as second test-crop; wheat was grown as a treatment-crop in the early years of the experiment but was replaced by rye. The yields of the 1972 wheat (Table 6) suggest that three-year leys

TABLE 5

Woburn Intensive Cereals experiment

Wheat (Cappelle), grain, tonnes/ha

	1972 kg N/ha				1971	1970
	63	126	188	251	Maximum yield (N)	Maximum yield (N)
(i)	2·1	3·6	3·4	3·8	5·0 (188)	3·2 (188)
(ii)	1·2	2·1	2·6	1·8	3·8 (188)	2·6 (188)

(i) After ley, potatoes
(ii) Continuous wheat since 1966

Basal dressing: 126 kg P_2O_5, 251 kg K_2O/ha

TABLE 6

Woburn Ley–Arable experiment

Wheat 1972, second text-crop (Cappelle), grain, tonnes/ha

Previous cropping	N (kg/ha) 0	63	126	189	Mean
L (P)	3·6	5·1	4·8	3·8	4·3
L (A)	3·0	5·2	5·0	4·0	4·3
S (P)	3·7	5·4	5·3	4·1	4·6
S (A)	2·8	4·9	5·0	4·0	4·1
AH (P)	1·8	4·2	5·0	4·7	3·9
AH (A)	2·6	5·3	4·7	4·3	4·2
AR (P)	2·2	4·7	4·8	4·7	4·1
AR (A)	3·0	5·5	5·0	4·4	4·5

Symbols: L = 3-year ley
S = 3-year sainfoin
AH = potatoes, rye, hay
AR = potatoes, rye, carrots
(P) = rotation permanent
(A) = rotations in rotation; symbol indicates last rotation

Basal dressing: 58 kg P_2O_5, 58 kg K_2O/ha

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of grass or sainfoin do not cause large increases in the maximum yield of wheat grown in the second season after the leys are ploughed. Even the extreme treatment on which an arable system has been followed without any leys (three-year or one-year) since 1938 (AR(P) in the table) gave a maximum yield only 0·3–0·6 tonne/ha less than the systems in which three-year leys have been grown every five years since 1938 (L(P), S(P) in the table). The amount of N required for maximum yield was 63 kg or a little more except after AH(P) where 126 kg N gave appreciably more than 63 kg.

A curious feature of the yields is that the effect of leys grown in the preceding cycle (i.e. in 1963–65) was larger than that of leys in the current cycle (i.e. in 1968–70) (Table 7).

The residual effect of chloropicrin and aldicarb applied to potatoes in 1971 varied little between cropping systems, but decreased with increased N (Table 8).

TABLE 7

Woburn Ley–Arable experiment

Wheat 1972, grain, tonnes/ha

Cropping 1963–65	Mean of maximum yields 1972
L, S	5·3
AH, AR	5·0
Difference	0·3
Cropping 1968–70	
L, S	5·2
AH, AR	5·2
Difference	0·0

Symbols: L = 3-year ley
S = 3-year sainfoin
AH = potatoes, rye, hay
AR = potatoes, rye, carrots

Basal dressing: 58 kg P_2O_5, 58 kg K_2O/ha

TABLE 8

Woburn Ley–Arable experiment

Wheat 1972, grain, tonnes/ha

		N kg/ha				
		0	63	126	189	Mean
L, S	O	2·8	4·8	4·8	3·8	4·0
	F	3·8	5·4	5·2	4·1	4·6
Difference		+1·0	+0·6	+0·4	+0·3	+0·6
AH, AR	O	2·0	4·4	4·9	4·7	4·0
	F	2·9	5·3	4·9	4·4	4·4
Difference		+0·9	+0·9	0·0	−0·3	+0·4

Symbols: L = 3-year ley
S = 3-year sainfoin
AH = potatoes, rye, hay
AR = potatoes, rye, carrots
O, F = none, chloropicrin and aldicarb to potatoes 1971

Basal dressing: 58 kg P_2O_5, 58 kg K_2O/ha

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To sum up: very few experiments allow comparison of yields of wheat between 1972, 1971 and 1970 in normal farm rotations; the incidence of yellow rust on Joss Cambier obscures other seasonal effects on this variety. What evidence we have suggests that Cappelle wheat at Rothamsted in 1972 yielded 0·5–1·0 tonnes/ha more than in 1971 but at Woburn rather less than in 1971.

Barley. Julia barley was grown again on the Hoos Classical Barley experiment but in 1972, in this and other experiments discussed below, for the first time we used seed dressed with ethirimol as a protection against mildew (*Erysiphe graminis*). This seemed to be effective on all experiments and perhaps for this reason responses to N on Hoos Barley were better than in 1971 or 1970 (both with and without PKNaMg); the yield with PKNaMg and 144 kg N, 6·5 tonnes/ha, was the best ever recorded on these plots (Table 9). Elsewhere on the experiment, on the smaller sub-plots introduced in 1968,

TABLE 9

Hoos Barley experiment

Yields of selected treatments (and effects of Si) Barley (Julia), grain, tonnes/ha

	1972	1971	1970
Treatment			
None	1·9	1·6	1·0
N1	3·1	2·3	2·0
N2	3·6	2·7	2·1
N3	4·1	2·4	2·3
PKNaMg	1·6	2·0	1·5
N1PKNaMg	4·0	3·8	3·0
N2PKNaMg	5·7	5·9	4·4
N3PKNaMg	6·5	5·9	5·2
D	6·1	5·0	4·4
DN2	6·2*	4·8*	5·7
Effect of Si:			
Without P	+1·1	+1·7	+1·2
With P	0·0	+0·9	+0·2

Symbols: N1, N2, N3 = 'Nitro-Chalk' at 48, 96, 144 kg N/ha
P = Superphosphate annually, at 73 kg P_2O_5/ha
K = Sulphate of potash annually, at 110 kg K_2O/ha
Na = Sulphate of soda annually, at 16 kg Na/ha
Mg = Sulphate of magnesia annually, at 11 kg Mg/ha
Si = Silicate of soda annually, at 448 kg/ha
D = Farmyard manure annually, at 35 tonnes/ha

*Badly lodged

yields with 144 k N and residues of castor meal were 6·3–7·2 tonnes/ha. Barley after potatoes/beans yielded more than barley after barley by 1·3 tonnes where no N was given, but where 96 or 144 kg N was applied the difference was only 0·3–0·4 tonne/ha.

On the Ley–Arable, Julia barley gave greater maximum yields than in 1971; the difference varied from 0·4–1·0 tonne/ha on each field (Table 10). On Highfield (after old grass) 50 or 88 kg N gave the greatest yields, on Fosters (old arable) 88 or 126 kg was needed. Yields on Fosters were again better than on Highfield, in contrast to 1970. On the Ley–Arable, as on Hoos Barley, 1972 gave the best barley yields ever recorded.

On the Residual Phosphate Rotation experiment in Sawyers I Julia gave yields about half a tonne better than in 1971, about 2 tonnes more than in 1970; in Great Field IV, where some grain was taken by birds, the difference was smaller (Table 11).

On the Cultivation–Weedkiller Rotation experiment Julia yielded about 1 tonne/ha more than in 1971, 2 tonnes more than in 1970 (Table 12).

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TABLE 10

Rothamsted Ley–Arable experiment

Barley (Julia), grain, tonnes/ha

Previous cropping	1972 kg N/ha 0	50	88	126	1971 Maximum yield (N)	1970 Maximum yield (N)
			Highfield			
Lu	5·1	6·7	7·1	7·0	6·3 (50)	6·1 (126)
Lc	5·4	7·4	7·1	6·3	6·4 (126)	6·0 (50)
Ln	5·6	7·2	7·2	6·8	6·8 (50)	5·9 (88)
Ah	4·4	6·6	7·0	6·9	6·4 (50)	6·0 (126)
Rc Rn	5·8[9]	7·2[9]	6·7[9]	6·3[9]	6·6[9] (50)	6·7[3] (88) 6·6[3] (88)
			Fosters			
Lu	5·0	6·8	7·4	7·6	7·3 (88)	5·1 (88)
Lc	6·0	7·2	7·6	7·5	6·8 (88)	4·8 (88)
Ln	5·8	7·0	7·6	7·1	6·6 (126)	4·7 (88)
Ah	4·6	6·6	7·4	7·4	6·6 (126)	4·8 (126)
Rc Rn	5·6[9]	7·0[9]	7·2[9]	7·0[9]	6·8[9](126)	4·8[3] (50) 5·0[3](126)

Symbols: Lu = lucerne
Lc = clover-grass ley
Ln = all-grass ley
Ah = arable with hay

R = reseeded grass
c = PK but no N applied (as Lc)
n = PK and N applied (as Ln)

[3] 3rd crop after grass: followed potatoes, wheat
[9] 9th crop after grass; cropping as Ah meanwhile

Basal dressing: 38 kg P_2O_5, 76 kg K_2O/ha

TABLE 11

Residual Phosphate Rotation experiments

Barley (Julia), grain, tonnes/ha

P_2O_5 (kg/ha) as superphosphate	Sawyers I 1972	1971	1970	Great Field IV 1972	1971	1970
None	5·5	4·9	3·0	4·3	3·6	3·0
376 in 1960	5·6	5·2	3·5	4·3	3·1	4·0
63 annually	6·2	5·8	4·0	4·4	4·6	4·8

Basal dressing: 100 kg N, 63 kg K_2O/ha

TABLE 12

Cultivation–Weedkiller Rotation experiment

Barley (Julia), grain tonnes/ha

	1972	1971	1970
Ploughed	6·9	6·0	5·0
Rotary cultivated	6·8	5·8	4·6
Tine cultivated	6·8	5·8	4·6

Basal dressing: 94 kg N, 38 kg P_2O_5, 38 kg K_2O/ha

On the Woburn Intensive Cereals experiment, yields of barley were better than in 1971 (Table 13), barley in rotation by 1·2 tonnes/ha, continuous barley by 0·8 tonnes; yields in 1970 were rather less than in 1971.

Clearly 1972 was a good season for spring barley at Rothamsted and Woburn provided that mildew was held in check. Yields were exceptionally heavy, exceeding those of 1971 by 1 tonne/ha and those of 1970 by 1–2 tonnes. On other experiments not included in

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TABLE 13

Woburn Intensive Cereals experiment

Barley (Julia), grain, tonnes/ha

	1972 kg N/ha				1971	1970
	50	100	150	200	Maximum yield (N)	Maximum yield (N)
(i)	3·8	5·4	6·0	5·8	4·8 (200)	4·7 (150)
(ii)	1·9	4·5	5·4	5·2	4·6 (200)	4·1 (200)

(i) After ley, potatoes
(ii) Continuous barley since 1966

Basal dressing: 126 kg P_2O_5, 251 kg K_2O/ha

this summary yields of barley ranged to 8·6 tonnes/ha (68·8 cwt/acre), the greatest we have ever harvested. Any suggestion that yields of barley have ceased to increase (or started to decrease) in spite of improvements in varieties and husbandry can be refuted; at least on our two Farms research correctly applied is still able to increase barley yields.

TABLE 14

Yields of beans (Maris Bead) from selected treatments of the Classical experiments

		Grain, tonnes/ha		
Experiment	Treatment	1972	1971	1970
Broadbalk (i)	None	2·5	2·0	0·5
	N2	2·8	1·5	0·2
	N2P	1·2	0·5	0·8
	PKNaMg	3·6	2·7	0·8
	D	3·6	2·6	1·8
Hoos Barley (i)	None	2·4	—	—
	P	2·2	—	—
	KNaMg	3·2	—	—
	PKNaMg	3·3	—	—
	None (R)	3·2	1·8	1·1
	P (R)	2·9	1·4	0·7
	KNaMg (R)	3·1	1·7	0·9
	PKNaMg (R)	4·0	2·4	1·4
Barnfield (i)	None	3·1	1·3	0·4
	P	3·5	1·8	0·5
	PNaMg	3·7	1·6	0·5
	PKNaMg	3·6	1·6	0·4
	D	3·7	1·2	0·7
	DPK	3·6	1·3	1·2
(ii)	None	3·0	0·3	0·1
	P	3·3	0·4	0·2
	PNaMg	3·4	0·3	0·2
	PKNaMg	3·0	0·4	0·3
	D	2·7	1·6	1·0
	DPK	3·5	0·7	0·7

(i) No simazine. (ii) With simazine

Symbols: N2 = 'Nitro-Chalk' at 96 kg N/ha
P = Superphosphate annually, at 73 kg P_2O_5/ha
K = Sulphate of potash annually, at 110 kg K_2O/ha (Broadbalk and Hoos Barley), 275 kg K_2O/ha (Barnfield)
Na = Sulphate of soda annually, at 16 kg Na/ha (Broadbalk and Hoos Barley); agricultural salt annually, at 88 kg Na/ha (Barnfield)
Mg = Sulphate of magnesia annually, at 11 kg Mg/ha
D = Farmyard manure annually, at 35 tonnes/ha
(R) = Residues of castor meal last applied 1967

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Beans. Spring beans (Maris Bead) on the Classical experiments (Table 14) yielded much more grain than in 1971 or 1970; on some plots we harvested ten times the wretched crops of 1971 and 1970. Best yields in 1972 were 3·6–4·0 tonnes/ha, not quite equal to those we were able to achieve a few years ago. Although few plants were infected with viruses (see p. 142) many were infested with stem eelworm (see p. 167) and this probably caused some loss on most of the experiments here discussed. Note that P applied without K on Broadbalk and the Hoos Barley experiment decreased yields, probably because more K has been removed by crops grown in the past with P than without. On Barnfield, where the depletion of soil K is less complete, P slightly increased yields. Simazine did much less harm to beans on the fertiliser plots of Barnfield than in recent years.

On the Cultivation–Weedkiller Rotation too, bean yields in 1972 were much better than in 1971 or 1970 (Table 15).

TABLE 15

Cultivation–Weedkiller Rotation experiment

Beans (Maris Bead), grain, tonnes/ha

	1972	1971	1970
Ploughed	3·5	2·2	1·0
Rotary cultivated	3·0	2·0	0·5
Tine cultivated	3·1	1·9	0·6

Basal dressing: 56 kg P_2O_5, 113 kg K_2O/ha

Results of our experiments in 1972 suggest that, provided a means can be found of controlling the virus diseases that have been widespread in recent years, yields of beans may again be achieved that will make the crop successful in itself and not merely a break crop reluctantly accepted by cereal growers.

Potatoes. On Broadbalk yields of potatoes (Table 16) generally conformed to the pattern set in 1970, being 2–3 tonnes/ha less except on the plot receiving FYM and

TABLE 16

Yields of potatoes (King Edward) from selected treatments on the Classical experiments

Total tubers, tonnes/ha

Experiment	Treatment	1972	1971	1970
Broadbalk	None	10·8	7·8	12·6
	N4	8·1	9·2	10·5
	PKNaMg	16·2	9·6	19·1
	N8PKNaMg	38·8	45·6	41·8
	D	40·2	36·2	43·8
	DN4	41·4	49·4	49·1
Date of planting		19 April	3 April	30 April
Hoos Barley*	N6	19·1	18·8	19·1
	N6PKNaMg	36·9	36·6	33·6
Date of planting		19 April	2 April	30 April

Symbols: N4, N6, N8 = 'Nitro-Chalk' at 96, 144, 192 kg N/ha
P = Superphosphate annually, at 73 kg P_2O_5/ha
K = Sulphate of potash annually, at 110 kg K_2O/ha
Na = Sulphate of soda annually, at 16 kg Na/ha
Mg = Sulphate of magnesia annually, at 11 kg Mg/ha
D = Farmyard manure at 35 tonnes/ha

*All with residues of castor meal, last applied 1967

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96 kg N as 'Nitro-Chalk' where the 1972 yield was 8 tonnes less than the 1970 yield; in 1972 the addition of N to the FYM gave little increase. 1971, by contrast, gave smaller yields than 1972 without N, larger ones with N. Yields on the Hoos Barley experiment varied much less from year to year.

On the Residual Phosphate Rotation experiments yields without P were less in 1972 than in 1971 or 1970 but with P applied annually, or in a large dose in 1960, 1972 yields were intermediate between those of 1971 and 1970 (Table 17).

On the Cultivation–Weedkiller Rotation experiment (with plenty of P to all plots) differences between the three seasons were small (Table 18).

TABLE 17

Residual Phosphate Rotation experiments

Potatoes (Majestic), total tubers, tonnes/ha

P_2O_5 (kg/ha) as superphosphate	Sawyers I			Great Field IV		
	1972	1971	1970	1972	1971	1970
0	17	24	23	23	28	29
376 in 1960	24	23	28	28	28	34
188 annually	39	42	34	44	46	43

Basal dressing: 251 kg N, 251 kg K_2O/ha

TABLE 18

Cultivation–Weedkiller Rotation experiment

Potatoes, total tubers, tonnes/ha

	1972 (Pentland Crown)	1971 (Pentland Crown)	1970 (Pentland Dell)
Ploughed	39	41	33
Rotary cultivated	36	34	33
Tine cultivated	38	37	37
Date of planting	19–20 April	8 April	1 May

Basal dressing: 163 kg N, 163 kg P_2O_5, 251 kg K_2O/ha

On the Woburn Ley–Arable experiment (Table 19) yields of potatoes were good, but much less than the exceptional ones of 1971. Again, there were substantial increases for chloropicrin plus aldicarb on most cropping systems, including some in which potatoes have not been grown unduly often, such as L(A) on which (apart from test-crops common to all plots) potatoes have been grown only three times since 1938.

On the Woburn Intensive Cereals experiment (Table 20) average potato yields in 1972 were intermediate between those of 1971 and 1970; the difference between the sites of the Barley and Wheat experiments was less than in 1971.

To sum up: yields of potatoes in 1972 were good but not exceptionally so; differences in the three years have not been great, except on the Woburn Ley–Arable where the remarkable yields of 1971 were not equalled in 1972. There was an indication that fertilisers produced rather larger increases in 1972 than in recent years.

Garden clover

A fresh sowing was slow to establish and yields were poor. The untreated plot gave a total yield of 3·1 tonnes dry matter/ha (three cuts) increased by magnesium alone to 4·6 tonnes and by magnesium and nitrogen together to 5·5 tonnes. (McEwen)

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TABLE 19

Woburn Ley–Arable experiment

Potatoes, first test crop (Maris Piper), total tubers, tonnes/ha

Previous cropping	1972 O	1972 F	1971 O	1971 F
L (P)	54	56	60	73
L (A)	46	55	63	76
S (P)	52	55	72	85
S (A)	48	54	65	75
AH (P)	43	51	50	67
AH (A)	49	56	56	85
AR (P)	42	48	46	58
AR (A)	46	51	64	79
Date of planting	29 March		30 March	

Note: Sub-plots of AH, AR that received fumigant to treatment crop potatoes have been omitted

Symbols: O = no fumigant
F = chloropicrin plus aldicarb in current year
L = 3-year ley
S = 3-year sainfoin
AH = potatoes, rye, hay
AR = potatoes, rye, carrots
(P) = rotation permanent
(A) = rotations in rotation; symbol indicates last rotation

Note: plots of treatments AH, AR have carried potatoes more frequently than those of L, S since 1938.
Basal dressing: 255 kg N, 255 kg P_2O_5, 393 kg K_2O/ha (with additional K_2O to certain plots)

TABLE 20

Woburn Intensive Cereals experiment

Potatoes (Majestic), total tubers, tonnes/ha

After Classical experiment on:	1972	1971	1970
Wheat	36	35	32
Barley	41	46	34
Date of planting	18 April	30 March	22 April

Basal dressing: 134 kg N, 114 kg P_2O_5, 228 kg K_2O/ha

Mass selection of spring beans

At harvest 1971 plants of beans (variety Maris Bead) were sorted according to the number of pods per stem:

(i) 1–4
(ii) 5–8
(iii) 9–12
(iv) 13–24 (the largest number encountered).

All plants were free of seed-borne viruses.

In 1972 unselected seed from the same stock yielded 4·9 tonnes grain/ha; none of the selections gave a significantly different yield. (McEwen)

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Irrigation, nitrogen fertiliser and sucrose for spring beans

A microplot experiment tested all combinations of the following on field beans (variety Minor):

(i) none, irrigation (total 32 mm) for three weeks from start of flowering
(ii) none, 150 kg N/ha, as 'Nitro-Chalk', just before flowering
(iii) none, 150 kg sucrose/ha, applied as foliar spray, half when first flowers seen, half two weeks later.

Untreated plots gave 4·2 tonnes grain/ha, increased by irrigation to 4·7 tonnes and by N alone to 4·6 tonnes. Greatest yield, 4·9 tonnes, was obtained by irrigation and nitrogen together. Sucrose did not affect yield. (McEwen)

Control of frit-fly in maize and sweet corn

An experiment was done to find out whether maize and sweet corn, which are different cultivars of the same species (*Zea mays*), differ in susceptibility to attack by frit-fly (*Oscinella frit*) and to compare methods of control. The cold weather at and after sowing delayed growth and the grain maize variety (Pioneer 131) gave no good grain; the sweet corn (Early King) yielded few cobs but they were of normal quality. Frit-fly did no damage on the experiment. (Wilson, with Stephenson, Entomology Department)

Maize for grain at Woburn

Two experiments were sown with maize which germinated slowly in the cold weather of May and June. Growth was slow and when the protective netting was blown off pheasants severely damaged the crop so that the experiments had to be abandoned.

Suppression of couch grass by ryegrass or clover undersown in barley or beans

An experiment similar to that of 1971 (*Rothamsted Report for 1971*, Part 1, 257–258) tested the effect on the growth of planted rhizomes of couch (*Agropyron repens*) of undersowing Italian ryegrass or red clover in crops of spring barley and spring beans. The couch grew slowly in the dry cold weather of May and June and most of the yields recorded in November were less than those of 1971; in this experiment ryegrass competed with couch more effectively than clover. Yields of couch (whole plant) were:

Couch grass (whole plant), air dry, g per station

	Barley	Beans
Undersown		
None	0·7	2·5
Ryegrass	0·4	0·8
Clover	0·5	1·9

(about 0·7 g dry couch planted per station)

An unexpected result of this experiment was that the beans were visibly affected by the undersown crops; clover lessened their height by 5–10 cm, ryegrass by about 15 cm. Eye estimates suggested decreases of yield of beans of about 20% (clover), 60% (ryegrass). Competition above ground seems unlikely to be the cause of the decreased yield of beans, because the beans were taller at all times. Competition below ground, for water or nutrients such as K or (early in the season) nitrate-N, probably caused the decrease. The barley was not obviously affected by competition from the undersown crops. (Barnard and Dyke)

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The choice of a break crop before wheat

The last of the present series of experiments comparing beans, oats, clover and maize as break crops (with barley included to represent continuous cereal-growing) came into the first test crop, winter wheat, in 1972. The preliminary crops all grew well in 1971; trefoil (undersown in some plots of barley and oats) on average decreased the yields of the nurse crops by 0·02 tonne/ha. Trefoil sampled just before ploughing down contained 49 kg N/ha after oats, 65 kg N after barley; clover contained 88 kg N; weeds, etc., on other plots contained 2–7 kg N. The wheat of 1972 was moderately infected with yellow rust (*Puccinia striiformis*); the infection was more severe the more 'Nitro-Chalk' was given.

Although in general the yields of wheat confirmed earlier conclusions (*Rothamsted Reports for 1970*, Part 1, 236–237, and *for 1971*, Part 1, 258–259) that break crops have little effect on the potential yield of wheat except through the lessening of take-all infection, there were some new points (Table 21):

TABLE 21

Wheat after break crops (omitting undersown plots)

Grain, tonnes/ha

	'Nitro-Chalk' to wheat (kg N/ha)				
Preceding crop	0	50	100	150	Mean
Barley	2·26	3·93	5·17	4·56	3·98
Oats	3·19	5·13	5·54	5·09	4·74
Beans	4·54	5·48	5·51	4·95	5·12
Clover	5·74	6·06	5·21	4·60	5·41
Maize with 100 kg N	4·23	5·59	5·40	5·03	5·06
Maize with 200 kg N	5·28	5·84	5·37	4·78	5·32

Wheat after break crops; increases for trefoil ploughed down

Grain, tonnes/ha

	'Nitro-Chalk' to wheat (kg N/ha)				
Preceding crop	0	50	100	150	Mean
Barley	+1·67	+0·80	−0·27	−0·07	+0·53
Oats	+1·06	+0·16	+0·15	−0·06	+0·33
Mean	+1·36	+0·48	−0·06	−0·06	+0·43

(i) 50 kg N as 'Nitro-Chalk' was enough for maximum yield of wheat after clover and after maize; 100 kg N was needed after barley and oats whilst after beans 50 kg and 100 kg N gave equal yields. 150 kg was excessive in all sequences.

(ii) The residual effect of 200 kg N applied to maize (compared with 100 kg) was 1 tonne/ha where no 'Nitro-Chalk' was applied to wheat, 0·25 tonne with 50 kg N, negligible with more N. (In 1971 the corresponding effect without 'Nitro-Chalk' was 0·4 tonne.)

(iii) Maximum yields after oats and beans exceeded the maximum after barley by about 0·3 tonne, much less than in previous experiments, although the differences in take-all infection were similar in all three experiments (see p. 137).

(iv) Maximum yield after clover was greater than after oats or beans; maxima after maize were at least equal to those after oats or beans.

(v) The effect of trefoil ploughed down for wheat was large where no 'Nitro-Chalk' was given but (except with 50 kg N after barley) was very small where 'Nitro-Chalk' was applied. (Dyke and Prew, Plant Pathology Department)

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Staff

Dyke attended a seminar on public relations arranged by the Agricultural Research Council in February.

Elisabeth Hind joined the Section in October for a year; she holds a Natural Resources Studentship in Agriculture from the Overseas Development Administration and is studying statistical and practical aspects of field experimentation working part-time with Wimble (Statistics Department), part with members of the Section.

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