

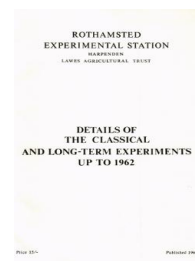
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Details of the Classical and Long-term Experiments Up to 1962

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Ley-arable Rotations- Rothamsted

Rothamsted Research

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LEY-ARABLE ROTATION EXPERIMENT, ROTHAMSTED
HIGHFIELD AND FOSTERS FIELD, 1949 ONWARDS

The purpose of the experiment is to study the effect of various three-year leys on the fertility of the soil as measured by a sequence of three arable test crops. The experiment also includes plots of old permanent grass (Highfield only) and plots of reseeded permanent grass on both fields. It is part of the experiment to measure the output of herbage crops of different duration and management.

The four 6-course rotations being compared are:-

			Lucerne	Ley	Cut grass	Arable with hay
Treatment crops	1st year		Lucerne	Grazed ley	Cut grass	1 year hay
"	"	2nd "	"	" "	" "	Sugar beet
"	"	3rd "	"	" "	" "	Oats
Test	"	4th "	Wheat	Wheat	Wheat	Wheat
"	"	5th "	Potatoes	Potatoes	Potatoes	Potatoes
"	"	6th "	Barley	Barley	Barley	Barley *

*undersown

The Highfield site had been under old permanent grass for many years and has no record of arable cultivation. Fosters was a very old arable field with no long leys in recent years.

Six blocks, one for each of the six phases of the rotation, were put down in duplicate making 12 blocks in each field. On Highfield in addition to the ley arable sequences every block included one plot of the old pasture undisturbed and another plot that had been broken up and resown to long-term grass in the spring of 1949, 1950 or 1951 by phases. On Fosters only the reseeded grass could be tested.

The above crops were grown on main plots of 0.091 acres on both fields, but these were harvested in halves, quarters, and occasionally by eighths to test manurial treatments.

The seed mixtures, which have been unchanged till 1961 are:-

1 year hay: 18 lb. Perennial Ryegrass S. 24
8 lb. Late Flowering Red Clover.
2 lb. Alsike Clover

28 lb.

Sown at 28 lb. per acre (40 lb. till 1954). Undersown in barley.

Lucerne: Du Puits (Provence in 1949) sown at 21 lb. per acre (34 lb. until 1952, 28 lb. 1953-1960).

Sown in rows 18 in. apart (12 in. until 1954).

LEY-ARABLE (R)

3 year grazed ley and reseeded grass:

- 5 lb. Italian Ryegrass
- 8 lb. Perennial Ryegrass S. 23
- 8 lb. Perennial Ryegrass Kent Indigenous
- 4 lb. Cocksfoot S. 26
- 4 lb. Cocksfoot S. 143
- 2 lb. Timothy S. 48
- 2 lb. Timothy S. 50
- 6 lb. Late Flowering Red Clover
- $\frac{1}{2}$ lb. New Zealand White Clover
- $\frac{1}{2}$ lb. Kent Indigenous White Clover

40 lb.

Sown at 44 lb. per acre (56 lb. till 1954). Sown in the open.

- Cut grass:
- 6 lb. Italian Ryegrass
 - 16 lb. Cocksfoot S. 26
 - 4 lb. White Clover S. 100
 - 2 lb. Alsike Clover

28 lb.

Sown at 33 lb. per acre (40 lb. till 1954). Sown in the open.

The experiment has been modified from time to time as improvements suggested themselves and it may be regarded as falling into three periods.

First Period: 1949-1954. The cropping for this first cycle was as previously stated except that in the purely arable rotation the second treatment crop was potatoes (Majestic) and the third treatment crop was barley (Plumage Archer till 1953, then Proctor).

All plots had a basal dressing of phosphate and potash given as compound 0:13:13, for the individual crops the applications were according to good practice but all plots received the same total amount of P_2O_5 and K_2O (2.4 cwt.) during a complete rotation.

All treatment crops (except lucerne which received no nitrogen) were grown yearly at low nitrogen level (N_1) and at high nitrogen level (N_2) and the following test crops were similarly treated. These treatments were factorial on quarter plots (N_1 v. N_2 on treatment crops) x (N_1 v. N_2 on test crops) all dressings being cumulative.

Dung (D) at 12 tons per acre was tested on all potato crops, the test crop on all four rotations and the treatment crops of the arable rotation. The residual effect of dung appears in the following cereal crops and leys, so the quarter plots gave the following arrangement:-

Rotation	Applied to treatment crops	Applied to test crops	Replication on each field in each phase
Lucerne	Nil	x (N_1 v. N_2)(0 v. D)	2
Ley, cut grass	(N_1 v. N_2)	x (N_1 v. N_2)(0 v. D)	1
Arable	(N_1 v. N_2)(0 v. D)	x (N_1 v. N_2)(0 v. D)	$\frac{1}{2}$

LEY-ARABLE (R)

The permanent and reseeded grass was managed in a three year cycle, two years sheep grazing and one year hay with aftermath grazing. The 3 year ley was grazed by sheep and never cut.

The following six grass treatments each had its own team of grazing sheep which moved round the replicates for as many cycles as the season would permit. The number of grazing days and the live weight gains were recorded:-

- (1) 3 year ley, all ages, low N level 6 plots per field
- (2) 3 year ley, all ages, high N level 6 " " "
- (3) Reseeded grass, low N level 8 " " " (12 after hay cutting)
- (4) Reseeded grass, high N level 8 " " " " " " "
- (5) Old permanent grass, low N level (Highfield only) 8 plots (12 after hay cutting)
- (6) Old permanent grass, high N level (Highfield only) 8 plots (12 after hay cutting)

Grazing was by quarter plots of 0.022 acre which gave food for one day only. When a fold was ready for grazing a single transverse cut located at random was made with a "Roto-scythe" to give an estimate of yield and provide material for analysis. The aim was to graze down to the level of the sample cut in one day. The stocking varied between 4 and 7 sheep per fold. No leaving cut was made. Sheep were weighed at the beginning of a grazing cycle but were not weighed again till there was no more keep for them on any of the replicates of their appropriate treatment.

The fertiliser dressings during this first period were:-

Table 35
LEY-ARABLE ROTATION EXPERIMENT, ROTHAMSTED
Nutrients cwt. per acre
N on $\frac{1}{4}$ plots unless otherwise stated

	'Nitro Chalk'		Basal Dressing compound 0:13:13	
	N ₁	N ₂	P ₂ O ₅	K ₂ O
Grazed ley, 1st year	0.075 ^(a)	0.15	0.6	0.6
2nd and 3rd year	0.075 ^(a)	0.15	0.3	0.3
Cut grass, 1st year	0.15 ^(b)	0.3	0.6	0.6
2nd and 3rd year	0.15 ^(b)	0.3	0.3	0.3
Lucerne 1st year	-	-	0.6	0.6
2nd and 3rd year.	-	-	0.3	0.3
Reseeded and Old Grass				
Grazing years	0.075 ^(a)	0.15	0.3	0.3
Hay years	0.15 ^(c)	0.30	0.6	0.6
Wheat	0.3	0.6	0.15 ^(d)	0.15 ^(d)
Barley	0.2	0.4	0.15 ^(d)	0.15 ^(d)
1 year hay	0.3	0.6	0.15	0.15
Potatoes ^(e)	0.5	1.0	0.9	0.9

(a) in spring and same amount again in summer, N on half plots.

(b) for every cut.

(c) in spring and again for aftermath grazing.

(d) combine drilled.

(e) also tested 0 v. 12 tons dung, all manures in the ridges.
Nitrogen as Sulphate of ammonia.

LEY-ARABLE (R)

Second Period: 1955-1960. The most far-reaching change made at the beginning of this period arose out of an examination of potash withdrawals in the various treatment crops.

Soil and plant analysis had shown that very different amounts of K_2O were being removed from the soil by the various grass crops. Plots growing hay, cut grass and lucerne lost much more K_2O than the grazed plots. This difference was believed to be big enough to affect the yields of the test crops so in 1955 it was decided to give supplementary dressings of muriate of potash to plots that were cut, the amount of the dressings being based on estimates of the K_2O taken away in the crops. The amounts actually given year by year are:-

Table 36

LEY-ARABLE ROTATION EXPERIMENT, ROTHAMSTED

Supplementary potash dressings, K_2O cwt. per acre (as muriate except 1961)

The amounts were used on both Highfield and Fosters unless otherwise stated

(Figures in brackets refer to Fosters only)

Year	Phase of rotation	Lucerne	Cut grass	Old and re-seeded grass	To test crops after lucerne	after cut grass
1955	1st treatment	2.4	2.4	2.4	-	-
	2nd "	0.6	1.2	1.2	-	-
1956	1st "	3.0	3.0	1.2	-	-
	2nd and 3rd "	1.0	1.5	-	-	-
1957	1st "	3.0	3.0	1.0	-	-
	2nd "	1.0	1.5	1.0	-	-
	3rd "	1.0	1.5	-	-	-
	1st test	-	-	-	1.0	1.5
1958	1st treatment	3.0	3.0	2.4	-	-
	2nd "	1.2	2.4	1.2	-	-
	3rd "	1.2	3.6 (3.0)	-	-	-
	1st test	-	-	-	1.2	1.2
	2nd "	-	-	-	2.7(3.0)	2.7
1959	1st treatment	3.0 (4.0)	3.5 (4.0)	2.5 ⁽¹⁾	-	-
	2nd test	-	-	-	0.6(1.2)	2.4(1.8)
1960	None					
1961	All phases of "Arable" rotation,	3.0 cwt K_2O per acre as sulphate of potash.				
1962	None					

(1) Highfield old grass. Reseeded grass on both fields 3.0 cwt.

LEY-ARABLE (R)

Arising out of the above potash situation a beginning was made to measure differential potash (and phosphate) responses in test crop potatoes following the different leys. The original quarter plots were split to test an extra 0.9 cwt. K_2O , and also an extra 0.9 cwt. P_2O_5 above the basal dressing, i. e. (0.9 v. 1.8 cwt. K_2O) x (0.9 v. 1.8 cwt. P_2O_5). From 1955-1957 these tests were made on plots that had not yet received supplementary K_2O to the previous grass crop; from 1958 onwards they were made on plots that had received three or more adjustments. In the following barley crops the eighths which received high P or K to the potatoes received low P or K and vice versa to equalise the plots.

Other modifications introduced during this 2nd cycle were:

1955 (i) The third treatment crop of the "Arable" rotation was changed from barley to oats to reduce damage from foot rot diseases.

(ii) Nitrogen dressings on Highfield test crop barley reduced to 0 v. 0.2 cwt. N.

(iii) Hay from permanent and reseeded grass taken one in 6 years instead of once in 3. From 1956 the 1st year blocks were chosen for the hay crops.

1958 Grazing days only recorded on all grazed plots, no further sheep weights were taken. Cutting hay from the old and reseeded grass plots was discontinued. On the 2 plots of each type of grass in each phase, one was grazed as soon as it was fit, the other was shut up for an early silage crop. These treatments were applied in alternate years.

1960 Yields of arable hay, cut grass, and silage were estimated from two cuts 40" wide taken through each sub-plot with a flail type forage harvester.

NK compound 16:0:16 used in place of "Nitro-Chalk" for 2nd and 3rd year cut grass.

In 1958 also the PK compound 0:10:20 was used for certain basal dressings to raise the potash level. The scheme, in cwt. nutrients per acre, was:-

	P_2O_5	K_2O	Fertiliser
All cereals	0.15	0.3	(0:10:20)
2nd and 3rd year leys, grazed	0.3	0.6	(0:10:20)
Old and reseeded grass, grazed	0.3	0.6	(0:10:20)
Old and reseeded grass, silage	0.6	1.2	(0:10:20)
2nd and 3rd year cut grass	1.2	1.2	(0:16:16)
and for every cut	-	0.15 v. 0.3	(16:0:16)
Treatment crop potatoes	0.9	1.8	(0:10:20)
and 2nd and 3rd year lucerne			
1 year hay	0.6	0.6	(0:16:16)

LEY-ARABLE (R)

Interim system 1961: The following changes were made (for details see table 37):-

The treatment crops now had basal dressings of nitrogen instead of the former nitrogen tests.

1 year hay was cut twice, "Nitro-Chalk" being applied for each cut. Sugar beet replaced potatoes as the second treatment crop and the test of 0 v. 12 tons of dung was stopped.

Grazed ley received "Nitro-Chalk" at 0.22 cwt. N in two equal dressings, the P₂O₅ and K₂O for the 2nd and 3rd years were doubled. Cut grass received 0.22 cwt. N for every cut, in the 2nd and 3rd years potash equal to the nitrogen was also given for every cut using 16:0:16.

Test crops: Wheat tested four nitrogen levels on $\frac{1}{8}$ plots.

Potatoes: All plots had extra basal nitrogen and those without dung had extra basal P₂O₅ and K₂O. These additional basals were broadcast before ridging, the remaining basals and test manures were put in the ridges. Tests of P and K now on $\frac{1}{16}$ plots.

Permanent and reseeded grass: In the silage years the nitrogen level for silage and for the subsequent grazing was raised to 0.3 cwt. N in each case. In the grazing years the nitrogen level was raised to 0.22 cwt. N applied in two equal dressings.

Liming: On Highfield in 1949-1951 each set of 4 blocks received a corrective chalking in autumn as they came into experiment. In autumn 1952 a scheme of maintenance dressings was started, ground chalk being applied at the rate of 20 cwt. CaO per acre once every 6 years before barley. Commencing in 1958 the dressing was raised to 46 cwt. of ground chalk per acre.

On Fosters only blocks 10, 11, 12 needed a corrective dressing. This was applied at the rate of 2 tons ground chalk per acre in spring 1951.

Third Period: 1962 onwards. New seeds mixtures and new systems of management have been introduced in 1962 as follows:-

Plots formerly in "Cut Grass": Cocksfoot S37 at 30 lb. per acre.

Manuring: in seedbed 0.6 cwt. P₂O₅ and 1.2 cwt. K₂O per acre (as 0:14:28) and 0.6 cwt. N as "Nitro-Chalk" followed by 0.6 cwt. N and 0.6 cwt. K₂O (as 16:0:16) after each cut except the last.

These plots to be cut for silage.

Plots formerly in "Grazed Ley":

mixture composed of:-

5 lb. Timothy S51
6 lb. Meadow Fescue S215
1 lb. White Clover S100

12 lb

sown at 33 lb. per acre.

LEY-ARABLE (R)

Table 37
LEY-ARABLE ROTATION EXPERIMENT, ROTHAMSTED

Crop	N	Fertilizer Application (cwt. per acre)		Materials
		P ₂ O ₅	K ₂ O	
Test crops				
Wheat				
Highfield	0.0, 0.3, 0.6, 0.9 (spring)	0.3	(combine drilled)	0.6 (combine drilled)
Fosters	0.0, 0.4, 0.8, 1.2 (spring)	0.3	(combine drilled)	0.6 (combine drilled)
Potatoes				
Highfield	Basal 0.75 (in ridges)	0.6* 0.9 v. 1.8	(before ridging) (in ridges)	0.9* (before ridging) 0.9 v. 1.8 (in ridges)
Fosters	Plus 0 v. 0.5 (broadcast before ridging) Basal 1.00 (in ridges) Plus 0 v. 0.5 (broadcast before ridging)			
Barley				
Highfield	0.0 v. 0.2 (all rotations) (seedbed)	0.3 0.9 v. 0.0	(combine drilled) (in winter)	0.6 (combine drilled) 0.9 v. 0.0 (in winter) as super and M/K to balance dressings to potatoes
Fosters	0.2 v. 0.4 (except "arable") (seedbed) 0.3 v. 0.6 ("arable" only) (seedbed)			
Treatment crops				
Hay (cut twice)	0.6 (February) 0.6 (after first cut)	0.6	(February)	0.6 (February) 0.6 (after first cut)
Sugar beet	1.0 (seedbed)	1.0	(seedbed)	1.4 (plough furrow) 1.0 (seedbed)

*only on sub-plots without dung

LEY-ARABLE (R)

Oats							
Highfield	0.2	(seedbed)	0.3	(combine drilled)	0.6	(combine drilled)	N/C and (0:14:28)
Fosters	0.4	(seedbed)	0.3	(combine drilled)	0.6	(combine drilled)	
Grazed Ley							
1st year	0.1125	(seedbed)	0.6	(seedbed)	0.6	(seedbed)	(0:20:20)
	0.1125	(mid-season)	-		-		N/C
2nd and 3rd years	-	(spring)	0.6	(winter)	1.2	(winter)	(0:14:28)
	0.1125	(mid-season)	-		-		N/C
	-		-		-		N/C
Cut Grass							
1st year	0.225	(seedbed)	0.5625	(seedbed)	0.5625	(seedbed)	(6:15:15)
	0.225	(after each cut except last)	-		-		N/C
2nd and 3rd years	-		1.2	(winter)	1.2	(winter)	(0:20:20)
	0.225	(for each cut)	-		0.225	(for each cut)	(16:0:16)
Lucerne							
1st year	nil		0.6	(seedbed)	0.6	(seedbed)	(0:20:20)
2nd and 3rd years	nil		0.9	(winter)	1.8	(winter)	(0:14:28)
Reseeded and Permanent Grass							
"Silage" years	-	(spring)	0.6	(winter)	1.2	(winter)	(0:14:28)
	0.3	(after silage out)	-		-		N/C
All grazing years	-		0.3	(winter)	0.6	(winter)	(0:14:28)
	0.1125	(spring)	-		-		N/C
	0.1125	(mid-season)	-		-		N/C

Key to materials

- N/C: "Nitro-Chalk" 21
- S/A: Sulphate of ammonia
- M/K: Muriate of potash
- (8:8:8) etc.: granular compound (percentage of N : P₂O₅ : K₂O)

LEY-ARABLE (R)

Manuring: 0.6 cwt. P₂O₅ and 1.2 cwt. K₂O per acre (as 0:14:28) in seedbed.

0.6 cwt. K₂O (as muriate) after each cut except the last.

No N.

These plots to be cut at early silage stage (4"-6").

Old Grass (Highfield):- each plot split lengthwise and the two halves allocated to manuring and management as for the two types of ley above. Grazing discontinued.

Reseeded Grass:

Manuring and management (grazing and silage cuts) as since 1958, pending the ploughing up for test cropping of certain plots. Manuring and management of "Cut Grass" and "Grazed Ley" plots sown in 1960 and 1961 to continue as previously specified (including grazing).

Barley:

4 levels of N are tested on $\frac{1}{8}$ plots:-

Highfield: 0.0, 0.1, 0.2, 0.3 cwt. N per acre as "Nitro-Chalk".

Fosters, "arable" rotation: 0.0, 0.4, 0.6, 0.8 cwt. N per acre as "Nitro-Chalk"

remainder: 0.0, 0.2, 0.4, 0.6 cwt. N per acre as "Nitro-Chalk".

For a summary of the results to 1960, see Rep. Rothamst. exp. Sta. for 1961, 173-180.

LEY-ARABLE ROTATION EXPERIMENT, ROTHAMSTED

Table 38

Wheat (1st test crop)

Grain at 85% dry matter: cwt per acre

Mean Yields and responses to N over 4 years 1957-60

	Mean yield		Response to N*	
	Highfield	Fosters	Highfield	Fosters
(1) Grazed ley	39.6	40.1	0.6	2.7
(2) Conserved ley	39.6	40.0	2.3	4.0
(3) Lucerne	42.7	46.2	2.2	2.9
(4) Arable	42.2	39.4	2.8	6.5
Mean	41.0	41.4	2.0	4.0

* 0.3 v. 0.6 cwt. N/acre.

Table 39

Potatoes (2nd test crop)

Total Tubers: tons per acre

Means over 3 years 1958-60

	Highfield	Fosters
(1) Grazed ley	16.4	15.8
(2) Conserved ley	16.4	15.8
(3) Lucerne	16.2	16.0
(4) Arable	14.9	14.7
Mean	16.0	15.6

LEY-ARABLE (R)

Table 40
Potatoes (2nd test crop)
Total Tubers: tons per acre
Mean responses to FYM, N, P and K over 3 years 1958-60

	Grazed ley	Conserved ley	Lucerne	Arable	Mean
Response to FYM (15 tons FYM per acre)					
Highfield	0.6	0.1	0.8	2.6	1.0
Fosters	2.2	1.4	2.0	2.1	1.9
Response to N (1.0-0.5 cwt. N per acre)					
Highfield	0.4	0.3	0.7	0.6	0.5
Fosters	0.7	0.7	1.0	1.4	1.0
Response to P (1.8-0.9 cwt. P ₂ O ₅ per acre)					
Highfield	0.4	0.5	0.0	-0.5	0.1
Fosters	0.6	0.4	0.2	0.7	0.5
Response to K (1.8-0.9 cwt. K ₂ O per acre)					
Highfield	0.4	-0.2	0.0	0.9	0.3
Fosters	0.1	0.4	0.3	0.0	0.2

Table 41
Barley (3rd test crop)
Grain at 85% dry matter: cwt per acre
Mean yields and response to N over 3 years 1959-61

	Mean yield		Response to N	
	Highfield	Fosters	Highfield	Fosters
(1) Grazed ley	44.6	46.9	0.0	4.4
(2) Conserved ley	46.0	46.0	1.8	2.5
(3) Lucerne	45.2	48.2	-0.6	4.9
(4) Arable	47.0	43.9	4.2	5.6
Mean	45.7	46.2	1.4	4.4

Note: The rates of N were 0.0 v 0.2 cwt per acre for Highfield and 0.2 v 0.4 cwt per acre for Fosters.

LEY-ARABLE (R)

Table 42
 Dry matter: cwt per acre
 Means over 10 years 1951-60

	Highfield			Fosters			
	Low N	High N	Mean	Low N	High N	Mean	
Reseeded grazed	37.8	40.9	39.4	34.8	35.3	35.0	
Old grazed	33.6	37.7	35.6	-	-	-	
Reseeded hay or silage aftermath grazed	47.9	50.9	49.4	39.1	41.6	40.4	
	20.5	24.4	22.5	21.0	22.1	21.5	
Total	68.4	75.3	71.9	60.1	63.7	61.9	
Old grass: hay or silage aftermath grazed	41.8	47.0	44.4	-	-	-	
	22.7	24.3	23.5	-	-	-	
Total	64.5	71.3	67.9				
Grazed ley	1st year	32.2	33.9	33.1	21.4	22.4	21.9
	2nd year	41.2	46.1	43.6	37.9	38.8	38.4
	3rd year	40.3	45.0	42.6	34.2	36.7	35.5
	Mean	37.9	41.7	39.8	31.2	32.6	31.9
Cut ley	1st year	53.0	58.6	55.8	34.1	40.0	37.1
	2nd year	61.5	77.8	69.6	59.0	69.8	64.4
	3rd year	54.6	70.7	62.6	54.8	65.4	60.1
	Mean	56.3	69.0	62.7	49.3	58.4	53.9
Lucerne	1st year			41.8			35.4
	2nd year			92.6			97.3
	3rd year			75.6			97.9
	Mean			70.0			76.9
Seeds hay (Arable rotation)	50.1	52.6	51.3	43.7	50.5	47.1	

Note: Yields of grazed herbage are based on sample cuts.