

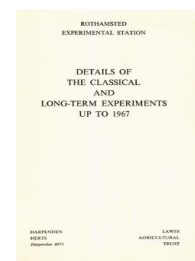
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## Details of the Classical and Long-term Experiments Up to 1967

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### Park Grass - Hay

#### Rothamsted Research

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## HAY, THE PARK GRASS PLOTS, 1856 ONWARDS

(See diagram, page 36)

The Park has probably been in grass for some centuries. There is no record of any seed having been sown. The herbage has been cut for hay each year since manurial treatments were first applied in 1856. The management of the aftermath following the first hay cut in each season varied in the early years of the experiment. It was grazed by sheep in the years 1856 to 1872 except for 1866 and 1870. In 1866, 1870, 1873, 1874, 1876, 1884, 1885, 1887, the aftermath was mown but not removed from the plots. In all other years the produce of the second and sometimes third cut has been carted and weighed either as hay or green.

TABLE 11

### *Manures applied annually since 1856*

(Unless otherwise stated)

For liming treatments see separate section below

(i) *Symbols, materials and rates of application*

N1, N2, N3	Sulphate of ammonia to supply 43, 86, 129 lb N (1)
N1*, N2*	Nitrate of soda to supply 43, 86 lb N. (For N* see note 19.)
P	363 lb superphosphate (18% P <sub>2</sub> O <sub>5</sub> ) to supply 65 lb P <sub>2</sub> O <sub>5</sub> (about 30 lb P) (2)
K	500 lb sulphate of potash (49% K <sub>2</sub> O) supplying 245 lb K <sub>2</sub> O (about 200 lb K) (3)
Na	100 lb sulphate of soda supplying about 14 lb Na (4)
Mg	100 lb sulphate of magnesia supplying about 10 lb Mg
Si	400 lb silicate of soda (5)
D	14 tons farmyard manure every fourth year
F	Fish meal every fourth year, to supply 56 lb N (about 6 cwt meal)

(ii) *Treatments*

Plot		
1	N1	(6)
2	None	(7)
3	None	
4-1	P	(8)
4-2	N2P	(8)
5-1	None	(9)
5-2	PK	(9)
6	PKNaMg	(8) (10)
7	PKNaMg	
8	PNaMg	(8) (11)
9	N2PKNaMg	
10	N2PNaMg	(8) (11)
11-1	N3PKNaMg	(12)
11-2	N3PKNaMgSi	(5) (12)
12	None	
13	DF	(13)
14	N2*PKNaMg	(14)
15	PKNaMg	(15)
16	N1*PKNaMg	(16)
17	N1*	(14)
18	N2KNaMg	(17)
19	D	(18)
20	DN*PK	(19)

# PARK GRASS

Hay each year since 1856



18 d	4
18 c (4.0)	
18/2 N <sub>2</sub>	
K	7
Na	
18 b Mg	
18 a	7
19/1	5
19/2	7
19/3	6
20/1	5
20/2	7
20/3	6

FYM every fourth year (1965, 1969)

FYM as 19  
1½ nitrate of soda,  
2 superphosphate,  
1 sulphate of potash  
in other years.

13 a	b	c	d
pH 7	FYM & FISH GUANO Alternately every 2yrs	(1.5)	pH 5
12	NO	MANURE	5
11/2	N <sub>3</sub> P K Na Mg + silic. of soda	(8.0)	4
11/1	N <sub>3</sub> P K Na Mg	(8.0)	4
10	N <sub>2</sub> P Na Mg		
9	(1.5)	(8.0)	4
8	N <sub>2</sub> P K Na Mg		
7	(3.0)	(7.0)	4
6	P Na Mg		
5/2	P K Na Mg		5
5/1	P K Na Mg		5
Area for micro.-plot experiments.			
4/2	(1.5) N <sub>2</sub> P	(9.0)	4
4/1	P		5
3	NO MANURE		5
2	NO MANURE		5
1	Ni (5.0)		4
14	N <sub>2</sub> * P K Na Mg		6
15	P K Na Mg		5
16	Ni* P K Na Mg		5
17	Ni*		6

7 pH in 1959

(1.5) Ground chalk, tons/acre, applied to "b" and "c" subplots, 1965-1968.

## PARK GRASS

### Notes

(1) Until 1916 the ammonia nitrogen was supplied as a mixture of equal parts of ammonium sulphate and ammonium chloride. Since 1917 only ammonium sulphate was used.

(2) Until 1888 the phosphate was made from 200 lb bone ash and 150 lb sulphuric acid, then superphosphate. 1897–1902 basic slag (400 lb).

(3) Until 1878 the standard dressing of sulphate of potash was 147 lb  $K_2O$ , it was then raised to 245 lb  $K_2O$ . Potassium dressings omitted 1917 and 1918.

(4) 1856–63 sulphate of soda at 200 lb.

(5) The silicate dressing began when plot 11 was divided in 1862 and from 1862 to 1870 equal parts of calcium and sodium silicate were used.

(6) Until 1863 14 tons of farmyard manure also.

(7) Until 1863 14 tons farmyard manure only.

(8) Sawdust at 18 cwt was applied to plots 6, 8, 10 until 1862, and on plot 4 until 1858.

(9) After ammonium salts 86 lb N until 1897.

(10) After ammonium salts 86 lb N until 1868.

(11) With K 1856–61. From 1864 to 1904 the dressing of sulphate of soda was 250 lb (500 lb 1862–63).

(12) Until 1881 the ammonium salts were applied at 172 lb N except in 1859–61 when the dose was 86 lb.

(13) Until 1897 complete fertiliser as plot 9 with 2000 lb of cut wheat straw in addition. From 1898 to 1904 as plot 9, no straw. The farmyard manure has been applied once every four years starting 1905, and the fish meal once every four years starting 1907. Since 1959 the fish meal dressing has been standardised at 0.5 cwt N (approximately 6 cwt meal).

(14) Since 1858.

(15) Since 1876. Nitrate of soda 86 lb N 1858–75.

(16) Since 1858. P omitted from plot 16 in 1866, 1867.

(17) Since 1905. From 1865 to 1904 P, K, Na, Mg, Si, and N equal to the amounts contained in 1 ton of hay (35 lb N).

(18) Every fourth year since 1905. From 1872 to 1904 65 lb  $P_2O_5$ ; 142 lb  $K_2O$ ; and 43 lb N as nitrate of soda.

(19) FYM every fourth year starting 1905; intervening years nitrate of soda (26 lb N) superphosphate (33 lb  $P_2O_5$ ) and sulphate of potash (49 lb  $K_2O$ ).

1872–1904: superphosphate (65 lb  $P_2O_5$ ) and potassium nitrate supplying about 43 lb N and 142 lb  $K_2O$ .

**Size of plots.** For manuring mostly 0.5 acre and 0.25 acre, a few 0.17 and 0.12 acre.

### Liming

**1881–1896.** The first liming was done in 1881, when a strip 11 yards wide on the north side of plots 1–13 received 2500 lb chalk. In 1883 and 1887, slaked lime was applied first to one half then to the other of all plots except 5. The rate was 2000 lb CaO except on plots 11-1 and 11-2 where 4000 lb was given. Plot 5 received 4000 lb in all; one half 2000 lb in 1883 and 2000 lb in 1896, the other 4000 lb in 1896.

**1903–1964.** In 1903 a regular liming scheme was started on the south halves of plots 1 to 4-2, 7 to 11-2, 13, 16. The dressing was ground lime (2000 lb CaO). The application was repeated in 1907 and 1915. In 1920 plots 14, 15 and 17 came into this scheme and in that year the dressing was 2500 lb CaO. Also in 1920 plots 18, 19 and 20 were each divided into

## PARK GRASS

three sections, one being left unlimed and the other two limed every four years:

Plot 18	61 and 35 cwt ground lime
19	28 and 5 cwt ground lime
20	25 and 5 cwt ground lime.

Lime was applied every fourth year, starting 1924, to the southern halves of plots 1 to 4-2, 7 to 11-2, 13 to 17, at 2000 lb CaO. Plots 18, 19, 20 received dressings as in 1920.

In 1956 the lime used contained a large proportion of calcium carbonate and it was decided that from 1960 the whole dressing should be applied as ground chalk equivalent to 2000 lb CaO for main plots, and appropriate amounts on plots 18, 19 and 20.

*From 1965.* In 1965 a new liming scheme was introduced to establish four levels of pH on most of the plots. Plots hitherto limed other than 5, 6, 12, 15, 18, 19, 20, were divided into four sub-plots (a, b, c, d), a and b on the south side (previously limed), c and d on the north side (previously unlimed). On sub-plot a the pH is maintained at the 1965 pH level by liming every fourth year; no lime is applied to sub-plot d. On sub-plots b and c lime is applied to establish and maintain pH 6 and 5 respectively. Plot 18-3 has the a, b split and 18-1 the c, d split. Plots 18-2, 19 and 20 are maintained at the 1965 pH level.

Dressings applied in 1965 and 1967 in the new scheme were as follows:

Plot	1965	1967 (tons CaCO <sub>3</sub> as ground chalk)
1c	2½	1¼
4-2b	1	—
4-2c	4½	2¼
9b	2	—
9c	3½	1¾
10b	1	—
10c	4	2
11-1b	5	2½
11-1c	4	2
11-2b	3	1½
11-2c	4	2
13c	1	—
18-1c	2	1

**Application of manures.** D, F, P, K, Na and Mg are applied in winter. N and N\* in spring (about March) in one application except (i) plots 11-1 and 11-2, where one-third of the annual dressing is applied about April and (ii) plot 14, where one half is applied about April. Lime is applied in winter.

**Harvesting.** For many years all operations were done by hand. The mowing machine was first used for the first cut in 1901 though it had been used for the second cut since 1881. The first cut was made into hay on its respective plots and weighed as such until 1959; the second cut is weighed green and yields are calculated from the dry matter figures. In 1959 a flail

## PARK GRASS

type forage harvester was compared with the ordinary cutter-bar machine on the first cut on parts of plots 1, 7, 11-1 and 13. The tabulated yields for this crop refer to hay made in the usual way. The second cut on all plots in 1959 was estimated entirely by forage harvester, taking two cuts per plot except plots 5 to 10, 13, 18 which had four cuts. From 1960 yields of both cuts have been estimated from two or four cuts by the forage harvester; at the first cutting the remainder of each plot is cut by mower and made into hay on the plot, to maintain continuity of husbandry, but at the second cutting the whole produce is cut by forage harvester and carried green. The positions of the sample cuts vary from year to year.

Note that yields given in Table 12 are expressed as dry matter. Yields given in the *Results of the Field Experiments* till 1959 are expressed as hay.

### References

- Further details of manuring: *Memoranda of the Field Experiments, Rothamsted, 1901*, pp. 20-23.
- Yields and botanical composition: Brenchley, W. E. (1958), *The Park Grass plots at Rothamsted, 1856-1949*. Revised by K. Warington. Harpenden; Rothamsted Experimental Station. (Reprinted 1969.)
- Brenchley, W. E. (1924). *Manuring of grassland for hay*. Rothamsted Monographs on Agricultural Science, London: Longmans, Green & Co.
- Warren, R. G. & Johnston, A. E. (1964) The Park Grass experiment. *Rep. Rothamsted exp. Stn for 1963*, 240-262.
- Plots 5 and 6 were taken out of the classical scheme in 1965 and used for micro-plot tests of N, P and K. For details see *Rep. Rothamsted exp. Stn for 1964*, p. 224, and for 1966, 49.

For yields see Table 12 on pages 40-42.

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TABLE 12  
*Park Grass*  
Herbage, dry matter: cwt  
Eight-year means

Plot	Treatment symbols	1920-27						1928-35						1936-43					
		Not limed		Limed		Not limed		Limed		Not limed		Limed		Not limed		Limed			
		First crop	Total	First crop	Total	First crop	Total	First crop	Total	First crop	Total	First crop	Total	First crop	Total	First crop	Total		
1	N1	13.6	20.9	15.7	21.3	11.7	15.7	15.1	18.4	6.1	10.8	12.4	16.2	6.1	10.8	12.4	16.2		
2	None	10.3	15.7	12.1	16.2	11.3	14.6	11.6	14.3	7.3	10.6	8.4	11.1	7.3	10.6	8.4	11.1		
3	None	8.8	12.8	9.6	13.2	9.7	12.4	9.6	11.8	6.5	9.2	7.9	10.6	6.5	9.2	7.9	10.6		
4-1	P	13.0	17.7	11.8	15.8	13.8	17.1	10.9	12.8	9.4	12.7	8.9	11.7	9.4	12.7	8.9	11.7		
4-2	N2P	15.5	19.6	24.4	31.9	14.6	17.5	27.3	31.7	10.6	15.7	21.5	26.2	10.6	15.7	21.5	26.2		
5-1	None	8.6	12.1	—	—	9.4	12.4	—	—	6.3	9.5	—	—	6.3	9.5	—	—		
5-2	PK	15.1	20.9	—	—	15.5	19.9	—	—	12.8	18.3	—	—	12.8	18.3	—	—		
6	PKNaMg	20.1	28.0	—	—	20.5	26.0	—	—	18.6	25.5	—	—	18.6	25.5	—	—		
7	PKNaMg	20.0	28.2	24.3	31.2	21.8	27.7	—	—	19.3	28.3	24.3	31.8	19.3	28.3	24.3	31.8		
8	PNaMg	13.4	19.4	11.3	16.2	15.3	19.9	12.1	16.2	12.8	17.9	10.5	14.6	12.8	17.9	10.5	14.6		
9	N2PKNaMg	26.2	35.6	38.7	48.6	32.9	39.9	45.0	52.3	26.2	36.2	33.3	41.8	26.2	36.2	33.3	41.8		
10	N2PKNaMg	19.7	26.6	29.8	38.6	21.2	26.0	32.5	38.6	14.6	21.6	27.1	34.0	14.6	21.6	27.1	34.0		
11-1	N3PKNaMg	31.4	45.4	43.4	55.4	35.2	47.6	47.1	55.8	22.9	40.0	38.1	50.6	22.9	40.0	38.1	50.6		
11-2	N3PKNaMgSi	38.7	50.8	44.1	57.2	40.0	53.7	47.8	59.7	30.7	48.7	40.3	55.8	30.7	48.7	40.3	55.8		
12	None	11.5	15.7	—	—	11.2	14.8	—	—	8.4	13.1	—	—	8.4	13.1	—	—		
13	DF	30.6	39.5	27.5	35.8	34.0	41.8	31.4	37.8	25.2	35.9	20.8	28.6	25.2	35.9	20.8	28.6		
14	N2*PKNaMg	39.4	49.5	35.9	43.0	42.7	52.1	41.8	47.9	36.6	45.9	34.7	41.7	36.6	45.9	34.7	41.7		
15	PKNaMg	21.8	29.7	18.5	25.1	21.2	27.1	21.4	25.3	14.1	19.6	19.9	24.8	14.1	19.6	19.9	24.8		
16	N1*PKNaMg	27.5	34.9	26.7	33.6	31.1	37.1	26.7	31.4	25.4	32.0	25.6	31.4	25.4	32.0	25.6	31.4		
17	N1*	16.4	22.4	18.4	24.1	16.4	20.5	20.0	23.0	12.9	17.3	15.9	18.8	12.9	17.3	15.9	18.8		
18	N2KNaMg	16.2	27.2	25.8†	36.6†	17.6	23.8	32.3†	38.7†	7.9	16.3	18.2†	21.3†	7.9	16.3	18.2†	21.3†		
				23.0†	31.7†	—	—	26.0†	31.3†	—	—	16.9†	20.5†	—	—	16.9†	20.5†		
19	D	20.6	28.4	17.9†	23.9†	21.4	28.2	18.7†	23.5†	19.8	27.3	18.6†	24.5†	19.8	27.3	18.6†	24.5†		
				18.8†	24.9†	—	—	20.5†	25.5†	—	—	19.4†	26.0†	—	—	19.4†	26.0†		
20	DN*PK	26.3	34.9**	25.7†	33.0†	31.6	38.0	28.8†	34.2†	26.9	34.4	23.7†	29.8†	26.9	34.4	23.7†	29.8†		
				29.7†	37.1†	—	—	30.4†	36.0†	—	—	25.0†	31.4†	—	—	25.0†	31.4†		

† Heavy liming. † Light liming. \*\* Excluding second crop, 1925.

PARK GRASS

TABLE 12 (continued)  
Park Grass

Herbage, dry matter: cwt

Plot	Treatment symbols	8-year means				1952-59				40-year means 1920-59			
		Not limed		Limed		Not limed		Limed		Not limed		Limed	
		First crop	Total	First crop	Total	First crop	Total	First crop	Total	First crop	Total	First crop	Total
1	N1	5.1	9.1	12.5	15.3	5.5	11.5	15.0	23.3	8.4	13.6	14.1	18.9
2	None	8.7	11.8	9.3	12.0	9.5	15.5	12.7	20.5	9.4	13.6	10.8	14.8
3	None	7.8	10.8	9.2	11.3	8.3	13.9	12.2	18.0	8.2	11.8	9.7	13.0
4-1	P	11.5	14.6	11.6	15.4	14.9	23.2	15.3	24.1	12.5	17.1	11.7	15.9
4-2	N2P	8.5	11.3	20.3	24.2	10.2	17.9	24.4	32.9	11.9	16.4	23.6	39.4
5-1	None	4.9	6.5	—	—	6.7	11.9	—	—	7.2	10.5	—	—
5-2	PK	11.0	15.9	—	—	17.5	27.1	—	—	14.4	20.4	—	—
6	PKNaMg	20.3	29.0	—	—	23.5	35.5	—	—	20.6	28.8	—	—
7	PKNaMg	18.7	27.4	29.0	36.9	22.6	34.1	29.5	41.8	20.5	29.2	27.0	35.3
8	PNaMg	15.8	22.3	11.2	15.1	18.1	27.8	15.3	23.9	15.1	21.5	12.1	17.2
9	N2PKNaMg	26.1	38.0	29.4	35.0	23.7	36.4	36.0	46.6	27.0	37.2	36.5	44.9
10	N2PNaMg	14.9	22.9	23.4	28.5	13.7	23.8	29.0	37.7	16.8	24.2	28.4	35.5
11-1	N3PKNaMg	23.9	42.7	40.1	49.5	21.9	45.0	40.8	56.5	27.1	44.2	41.9	53.6
11-2	N3PKNaMgSi	31.0	48.2	40.9	52.6	29.6	52.3	47.8	69.2	34.0	50.8	44.2	58.9
12	None	9.0	13.2	—	—	10.6	18.3	—	—	10.1	15.0	—	—
13	DF	21.8	30.0	26.0	33.6	27.3	40.9	25.8	40.1	27.7	37.6	26.3	35.2
14	N2*PKNaMg	34.2	44.7	32.8	39.7	39.1	55.2	39.2	53.7	38.4	49.5	36.9	45.2
15	PKNaMg	14.7	22.0	18.5	22.6	18.6	27.6	28.8	42.4	18.1	25.2	21.4	28.0
16	N1*PKNaMg	22.1	29.3	24.8	30.9	28.5	40.7	33.8	49.7	26.9	34.8	27.5	35.4
17	N1*	13.4	18.7	15.3	19.9	16.9	26.6	18.8	29.4	15.2	21.1	17.7	23.0
18	N2KNaMg	7.9	13.2	19.8†	24.0†	8.7	17.4	20.6†	27.8†	11.7	19.6	23.3†	29.7†
				17.7†	22.5†			20.2†	29.1†			20.8†	27.0†
19	D	20.6	28.3	20.5†	26.5†	24.8	36.9	23.5†	35.2†	21.4	29.8	19.9†	26.7†
				22.2†	27.8†			25.8†	38.7†			21.4†	28.6†
20	DN*PK	26.8	34.2	28.4†	34.5†	29.3	42.4	30.2†	42.8†	28.2	36.8**	27.4†	34.8†
				28.3†	35.7†			28.8†	42.0†			28.4	36.4†

† Heavy liming. † Light liming. \*\* Excluding second crop, 1925.



PARK GRASS

TABLE 12 (continued)  
Park Grass  
Herbage, dry matter: cwt

Plot	Treatment symbols	1960-63						44-year means 1920-63					
		Not limed			Limed			Not limed			Limed		
		First crop	Total	First crop	Total	First crop	Total	First crop	Total	First crop	Total		
1	N1	6.2	11.2	16.8	26.9	8.2	13.4	14.4	19.6	8.2	13.4	14.4	19.6
2	None	12.3	21.9	16.2	26.4	9.7	14.4	11.3	15.9	9.7	14.4	11.3	15.9
3	None	11.1	19.5	16.6	25.6	8.5	12.5	10.3	14.1	8.5	12.5	10.3	14.1
4-1	P	17.8	30.2	17.8	28.2	13.0	18.2	12.3	17.1	13.0	18.2	12.3	17.1
4-2	N2P	18.8	30.4	25.9	37.5	12.5	17.6	23.8	30.1	12.5	17.6	23.8	30.1
5-1	None	9.6	17.2	—	—	7.4	11.1	—	—	7.4	11.1	—	—
5-2	PK	19.1	35.1	—	—	14.8	21.8	—	—	14.8	21.8	—	—
6	PKNaMg	24.3	41.3	—	—	21.0	30.0	—	—	21.0	30.0	—	—
7	PKNaMg	26.7	42.0	39.6	61.6	21.0	30.3	28.1	37.6	21.0	30.3	28.1	37.6
8	PNaMg	18.9	32.5	17.8	30.0	15.4	22.4	12.6	18.4	15.4	22.4	12.6	18.4
9	N2PKNaMg	38.8	52.3	43.8	57.9	28.1	38.6	37.1	46.0	28.1	38.6	37.1	46.0
10	N2PNaMg	25.1	37.3	30.4	41.1	17.6	25.4	28.5	36.0	17.6	25.4	28.5	36.0
11-1	N3PKNaMg	40.9	67.1	47.8	68.2	28.3	46.2	42.4	54.9	28.3	46.2	42.4	54.9
11-2	N3PKNaMgSi	46.3	72.2	51.6	77.3	35.1	52.7	44.9	60.6	35.1	52.7	44.9	60.6
12	None	13.1	26.3	—	—	10.4	16.0	—	—	10.4	16.0	—	—
13	DF	31.2	49.2	33.6	56.2	28.1	38.7	27.0	37.1	28.1	38.7	27.0	37.1
14	N2*PKNaMg	44.1	61.1	42.8	56.2	38.9	50.5	37.4	46.2	38.9	50.5	37.4	46.2
15	PKNaMg	25.2	38.8	34.1	52.1	18.7	26.4	22.6	30.3	18.7	26.4	22.6	30.3
16	N1*PKNaMg	32.6	47.1	40.4	59.0	27.4	35.9	28.7	37.6	27.4	35.9	28.7	37.6
17	N1*	19.7	30.3	22.7	32.1	15.6	21.9	18.1	23.8	15.6	21.9	18.1	23.8
18	N2KNaMg	10.0	18.1	22.3†	32.0†	11.5	19.4	23.2†	29.9†	11.5	19.4	23.2†	29.9†
19	D	31.4	49.4	22.6†	33.0†	—	—	20.9†	27.5†	—	—	20.9†	27.5†
20	DN*PK	39.7	59.9	37.8†	54.6†	22.3	31.6	21.5†	29.3†	—	—	21.5†	29.3†
		—	—	36.4†	56.2†	—	—	22.7†	31.1†	—	—	22.7†	31.1†
		—	—	42.0†	64.9†	29.2	38.9**	28.7†	37.6†	29.2	38.9**	28.7†	37.6†
		—	—	40.0†	61.2†	—	—	29.5†	38.7†	—	—	29.5†	38.7†

‡ Heavy liming. † Light liming. \*\* Excluding second crop, 1925.