ROTHAMSTED RESEARCH

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

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Broadbalk - Wheat

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BROADBALK WHEAT EXPERIMENT, STARTED 1843

(See diagram, page 12)

The first experimental crop was harvested in 1844 after a rotation of turnips (FYM) 1839, barley 1840, peas 1841, wheat 1842, oats 1843, the last four crops being entirely unmanured. Wheat has been grown experimentally every year since. The manurial treatments varied somewhat in the first eight years, but the experiment attained its permanent form in 1852. Most of the treatments, with certain exceptions noted below, have been applied to their respective plots year after year since that date.

TABLE 1

Manures applied annually since 1852

(Unless otherwise stated)

(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
P	363 lb superphosphate (18% P_2O_5) to supply 65 lb P_2O_5 (about 30 lb P) (2)
K	200 lb sulphate of potash (49% K_2O) supplying 98 lb K_2O (about 80 lb K) (3)
Na	100 lb sulphate of soda, supplying about 14 lb Na (except plot 12, which gets 51 lb Na) (3)
Mg	100 lb sulphate of magnesia supplying about 10 lb Mg (except plot 14, which gets 28 lb Mg) (3)
FYM	14 tons farmyard manure
R	Castor meal to supply 86 lb N (4)

(ii) *Treatments*

Plot No.			
2A		FYM	(5)
2B		FYM	
3		None	(6)
5		PKNaMg	
6		N1PKNaMg	
7		N2PKNaMg	
8		N3PKNaMg	
9		N1*PKNaMg	(7)
10		N2	
11		N2P	
12		N2PNa	
13		N2PK	
14		N2PMg	
15		N2PKNaMg	(8)
16		N2*PKNaMg	(9)
17	even years:	PKNaMg	
	odd years:	N2	
18	even years:	N2	
	odd years:	PKNaMg	
19		R	(10)
20		N2KNaMg	(11)

Notes

(1) Until 1916 those plots which now receive sulphate of ammonia had a mixture of equal parts of ammonium sulphate and ammonium chloride (the 'ammonium salts' of the early reports). The ammonium salts were all applied in autumn till 1877; they were all applied in spring till 1883. In 1884 the present method was adopted of giving 21 lb N in the autumn and the remainder in spring. Except for the short period 1873–1877 plot 15 has always had the whole of its nitrogen in autumn.

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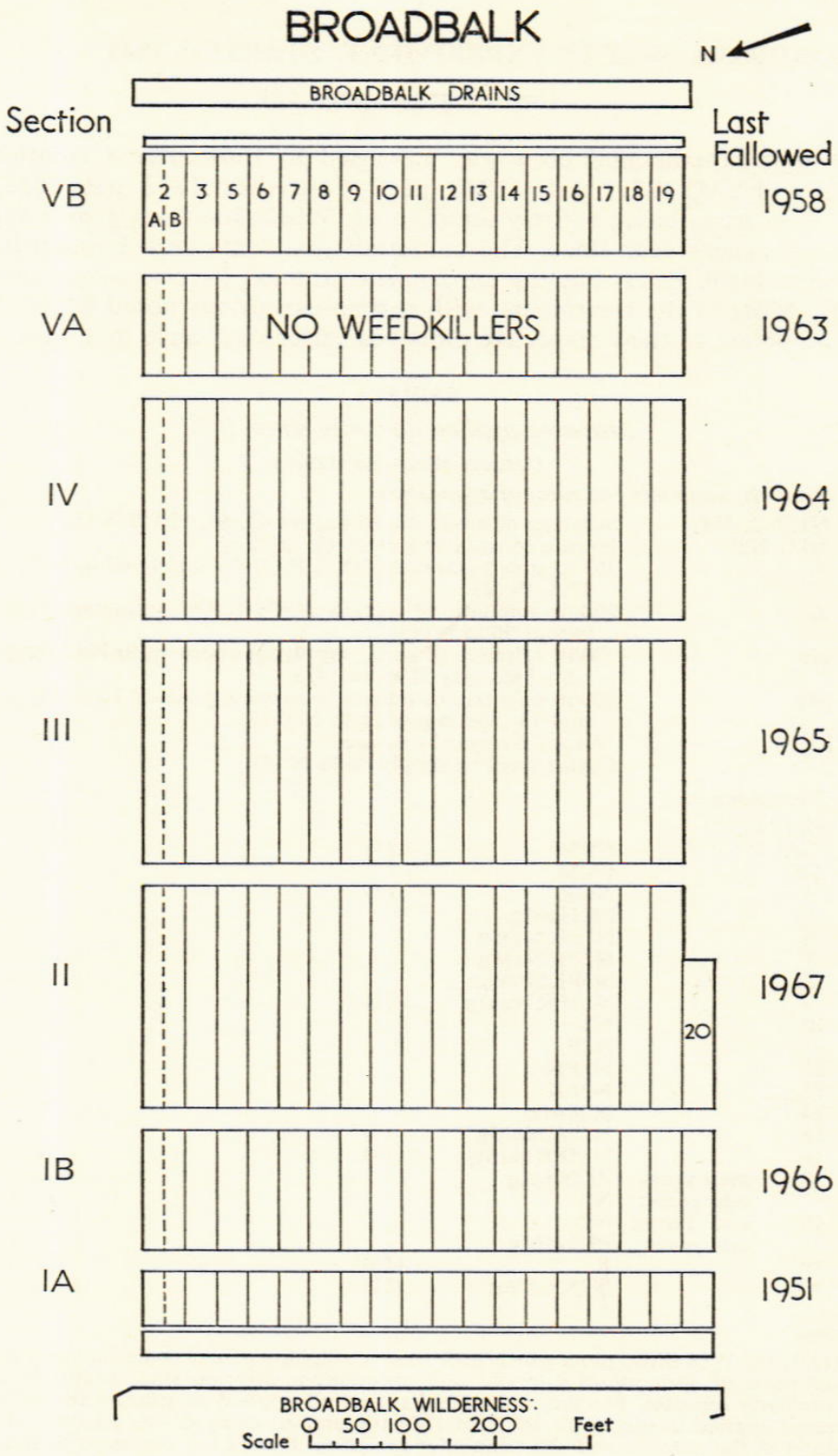

(2) Until 1888 superphosphate was made from 200 lb bone ash and 150 lb sulphuric acid; from 1889 it was made from mineral phosphate on the farm. (From 1898 to 1902 basic slag was used in place of superphosphate.)

(3) Until 1858 the dressing of sulphate of potash provided 147 lb K_2O and the sulphate of soda was applied at 200 lb. On plot 12 the sulphate of soda was 550 lb and on plot 14 the sulphate of magnesia was 420 lb.

(4) Castor meal since 1941, previously rape cake. From 1852 to 1878 the quantity of rape cake was 500 lb in addition to superphosphate and ammonium salts. In 1879 the minerals were stopped and the rape cake dressing was increased to provide about 86 lb N.

(5) In 1885 this new plot was made from two half plots, the one on the south had been unmanured since 1844 and the other half of the original plot 1 which had K Na Mg 1844–83 and was fallowed in 1884.

(6) Originally two half plots (3 and 4). 3 unmanured; 4 NP 1844–51 unmanured since 1852.

(7) Since 1894. From 1852 to 1893 plot 9 tested nitrate of soda at various rates (usually 550 lb supplying 86 lb N) with or without minerals.

(8) Since 1873. 1852–72: 15a N2PKNaMg; 15b N(1·5)PKNaMg + 500 lb rape cake. Since 1878 *all* manures are applied in autumn. N(1·5) indicates ammonium sulphate at 64 lb N.

(9) Since 1884. Plot 16 received 800 lb ammonium salts (about 172 lb N) with 'minerals' as on plot 5 from 1852 to 1864. It was then unmanured from 1865 to 1883.

(10) Since 1904. 19a 1852–1878 N(1·5)P + 500 lb rape cake; 1879–1904 rape cake; 19b 1852–1904 part unmanured, part headland.

(11) Started 1906 as a new plot.

FYM is ploughed down in autumn. P, K, Na, Mg and castor meal are applied to the seedbed in autumn. (No manures to fallow.)

For more detailed description of the materials used and minor changes in procedure see references 1–4.

Size of plots. The original plots consisted of two 'lands' each of $\frac{1}{4}$ acre side by side. (Plots 2A and 2B are of full length but a little narrower than the rest.) In the early days these lands sometimes carried different, but related, treatments. In 1894 the pairs of lands were thrown together to give $\frac{1}{2}$ acre plots each carrying a single treatment. It was these plots that were divided transversely into five equal sections in 1926.

Cropping and fallowing. Weeds have always been a serious problem on Broadbalk and in spite of regular hand-weeding and inter-row cultivation occasional bare fallows had to be given. The following is a record of the bare fallows and other cleaning operations.

1889	The wheat on one half of the field was drilled in wide rows (about 16 inches) to allow thorough inter-row cultivation.
1890	Same operation on the other half.
1904	Each plot was divided into halves longitudinally, one half being cropped and the other bare fallowed.
1905	Strips reversed.
1906–25	Crop grown on 12 inches rows to enable inter-row cultivation to be carried out.
1914	All the western half bare fallowed.
1915	All the eastern half fallowed.
1926	The field was divided transversely into five sections.
1926, 1927	Sections I, II, III bare fallowed.
1928, 1929	Sections III, IV, V, bare fallowed.

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BROADBALK

The whole field was cropped in 1930 and in 1931 a regular system of fallowing was started: the five sections being fallowed in turn, each section carrying four wheat crops in succession and then having one year's rest with sufficient summer cultivation to keep down weeds.

In 1956 Section I was divided into two: IA nearest the farm was assigned to continuous wheat with weedkillers as required but no fallows, while IB continued in the five-year cycle. In 1963 Section V was divided into two: VB assigned to continuous wheat with weedkillers while VA continued in the five-year cycle. The situation in the years 1957–67 is given in tabular form below.

System of cropping and fallowing

	IA	IB	II	III	IV	VA	VB
1957	6	1	F	2	3	4	4
1958	7	2	1	3	4	F	F
1959	8	3	2	4	F	1	1
1960	9	4	3	F	1	2	2
1961	10	F	4	1	2	3	3
1962	11	1	F	2	3	4	4
1963	12	2	1	3	4	F	5
1964	13	3	2	4	F	1	6
1965	14	4	3	F	1	2	7
1966	15	F	4	1	2	3	8
1967	16	1	F	2	3	4	9

1, 2, 3, 4 . . . first, second, third, fourth . . . crop after fallow (F).

Wild oats (*Avena ludoviciana*) have been hand-pulled on Broadbalk regularly since 1943. For a summary of the results of the first four fallowing cycles, 1935–54, see reference 5.

Weedkillers. On Section IA only: 1957 MCPA, 1958 mecoprop, 1959 2,3,6-TBA/MCPA mixture, 1960 mecoprop, 1961 and 1962 2,3,6-TBA/MCPA. IA and VB: 1963 mecoprop/2,4-D. All sections except VA: 1964 and 1965 dicamba/MCPA, 1966 and 1967 ioxynil/mecoprop. Also, to stubble in autumn 1959, Section IA only, 2,4-D; autumn 1965 to Section IA and plot 20 Section IB and II aminotriazole and ammonium thiocyanate, autumn 1966 aminotriazole and ammonium thiocyanate to Section IA only.

Liming. In recent years it was known that parts of Broadbalk were becoming acid. The acidity, which varied with position in the field, arose out of the continued use of ammonium salts and rape cake (now castor meal). In autumn 1954 a liming scheme was begun as follows:

Yearly dressings:

(*a*) on plots receiving sulphate of ammonia, 100 lb calcium carbonate per 14 lb N as sulphate of ammonia.

(*b*) on plots receiving castor meal, 50 lb calcium carbonate per 14 lb N as castor meal.

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In the first year the dressings of chalk on the ammonium sulphate and castor meal plots were applied at double the prescribed rates. Section V was divided transversely into two equal parts (A and B) which are harvested separately. Section VB, nearest the drain, received a single corrective dressing of chalk at 5 tons of calcium carbonate. In autumn 1963 Section VA and plot 19, Section IV, received extra chalk at 5 tons of calcium carbonate.

For details of the liming on Broadbalk see reference 6.

Harvesting. Until 1901 by hand; 1902–56 by binder; commencing in 1957 the plots were harvested by combine harvester, one combine cut per plot being weighed. Straw weights are taken after baling but some of the chaff, small cavings and dust are left on the plots.

Variety. Squarehead's Master since 1900. Previously Old Red Lammas 1844–48, Old Red Cluster 1849–52, Red Rostock 1853–81, Red Club 1882–99. For 1963 and subsequent years seed from Broadbalk (bulked from several plots and well mixed) was sown back on the field. Prior to 1963 new seed was bought each year.

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TABLE 2

Wheat: Broadbalk

Grain: cwt

Five-year means

Plot	Treatment symbols	1935–39 Years after fallow 1	2	3	4	1940–44 1	2	3	4	1945–49 1	2	3	4	1950–54 1	2	3	4	1955–59 1	2	3	4
2A	FYM since 1885	20·6	14·6	15·4	13·7	25·8	22·4	19·8	15·0	27·3	21·7	20·1	17·5	26·9	21·4	21·8	21·3	27·2	23·4	21·1	20·0
2B	FYM	21·2	18·5	16·3	14·9	26·9	24·1	24·5	19·4	28·3	25·1	21·6	18·9	26·4	22·8	22·4	23·2	27·8	24·8	22·7	22·8
3	None	12·5	6·4	7·1	7·1	19·0	10·0	10·6	10·6	16·5	10·2	8·0	7·9	16·4	9·4	9·1	9·0	17·3	10·4	11·0	11·0
5	PKNaMg	16·3	9·5	7·9	7·5	21·4	10·1	11·7	11·6	20·3	10·5	9·5	10·1	17·8	11·0	9·0	11·9	18·4	10·5	11·2	13·6
6	N1PKNaMg	19·4	11·9	10·0	10·9	24·3	14·3	15·2	15·3	23·1	14·1	11·4	11·4	21·3	15·1	12·7	14·2	22·0	15·3	14·7	16·8
7	N2PKNaMg	19·9	15·8	14·2	14·0	27·7	20·7	21·7	21·3	26·1	19·0	14·7	16·1	22·8	19·5	17·6	17·7	23·0	22·0	19·1	19·9
8	N3PKNaMg	20·7	18·5	15·8	14·9	27·2	22·9	22·9	23·4	27·0	24·1	20·4	19·3	24·2	23·0	20·8	22·6	26·1	25·0	21·1	21·0
9	N1*PKNaMg	19·2	13·6	11·5	12·3	25·4	17·3	16·5	18·4	21·7	15·8	12·6	12·7	20·5	16·1	15·9	16·1	22·9	18·4	17·5	15·5
10	N2	14·5	16·2	12·6	12·4	18·4	19·9	17·3	17·2	17·3	18·8	13·1	11·8	18·4	19·6	16·9	16·1	17·1	17·5	14·8	15·7
11	N2P	14·5	13·6	11·9	10·9	20·5	19·0	16·5	16·3	16·1	16·9	14·3	13·1	17·5	17·5	16·9	16·1	16·9	19·9	15·6	15·1
12	N2PNa	16·1	15·1	12·9	13·3	24·8	20·1	20·3	20·0	19·7	18·6	15·0	14·9	20·4	20·1	18·1	17·6	17·9	20·1	17·3	17·3
13	N2PK	19·4	14·8	13·3	14·4	28·3	19·3	19·1	19·4	26·0	18·3	14·6	14·3	23·6	19·5	17·0	17·5	23·3	20·4	18·6	18·5
14	N2PMg	16·3	15·5	13·0	13·9	26·5	19·8	19·4	19·2	20·7	21·2	16·1	15·1	22·3	18·5	19·0	17·1	18·8	20·0	16·8	17·0
15	N2†PKNaMg	18·8	14·4	12·9	14·0	26·4	17·9	18·3	19·3	23·3	16·6	14·5	14·4	24·6	15·6	14·9	15·0	22·6	16·2	15·3	16·4
16	N2*PKNaMg	20·0	17·3	15·5	15·5	29·6	23·5	24·2	23·4	26·2	21·5	18·3	18·3	24·4	22·8	20·5	20·9	24·7	23·7	22·6	22·1
17/18 (1)	N2	18·0	14·9	14·7	14·8	27·2	20·1	21·2	21·0	22·4	16·8	16·7	17·5	23·7	19·0	17·3	19·0	24·6	16·9	19·2	20·6
17/18 (1)	PKNaMg	15·2	8·1	6·4	7·5	22·4	9·5	8·6	9·2	17·8	9·1	7·2	6·8	19·8	10·6	8·2	6·6	17·3	10·0	9·0	8·9
19	R	19·1	15·2	12·5	13·3	28·3	19·3	17·7	18·0	22·5	18·1	15·2	15·3	20·5	16·8	14·2	15·5	21·9	16·4	13·9	16·3
20(2)	N2KNaMg	20·4	20·3	9·7	7·0	23·6	20·3	17·2	17·3	11·8	20·4	14·9	13·2	19·0	21·1	14·1	16·4	23·6	15·6	17·2	13·4

(1) Treatments in alternate years.
(2) Means of two years only per cycle.

* Nitrate of soda.
† Applied in autumn.

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TABLE 2 (*continued*)

Wheat: Broadbalk

Grain: cwt

Five-year means

Plot	Treatment symbols	1960–64 Years after fallow 1	2	3	4	Mean 1935–64 1	2	3	4	IA 1956–67	VB 1963–67
2A	FYM since 1885	27·3	25·4	21·7	20·2	25·8	21·5	20·0	17·9	20·9	22·9
2B	FYM	27·4	24·0	19·9	20·2	26·4	23·3	21·2	20·0	21·4	21·3
3	None	16·1	12·2	10·8	11·7	16·3	9·8	9·5	9·5	10·6	8·8
5	PKNaMg	17·9	13·2	12·3	13·9	18·7	10·8	10·2	11·4	12·1	13·6
6	N1PKNaMg	19·5	17·4	13·9	16·8	21·6	14·7	13·0	14·2	15·8	15·9
7	N2PKNaMg	21·2	21·6	18·4	19·3	23·4	19·8	17·7	18·0	21·5	18·9
8	N3PKNaMg	21·5	22·6	21·8	22·8	24·5	22·7	20·5	20·6	24·1	26·4
9	N1*PKNaMg	18·8	18·6	15·5	16·5	21·4	16·6	14·9	15·3	17·8	15·3
10	N2	14·4	20·6	18·7	18·6	16·7	18·8	15·5	15·3	15·0	13·8
11	N2P	17·0	20·6	13·4	17·2	17·1	17·9	14·7	14·8	18·9	15·3
12	N2PNa	13·4	19·7	16·3	18·6	18·7	19·0	16·6	16·9	20·5	16·3
13	N2PK	18·7	17·5	16·0	18·2	23·2	18·3	16·4	17·0	20·3	18·6
14	N2PMg	15·2	18·7	16·3	17·3	20·0	18·9	16·7	16·6	21·0	17·9
15	N2†PKNaMg	22·7	17·8	16·6	16·6	23·0	16·4	15·4	15·9	17·5	14·6
16	N2*PKNaMg	20·7	21·5	20·5	21·0	24·3	21·7	20·2	20·2	20·8	23·7
17/18 (1)	N2	14·4	9·5	7·9	9·3	17·8	9·4	7·9	8·0	8·2	9·3
17/18 (1)	PKNaMg	20·7	20·9	18·6	19·9	22·8	18·1	17·9	18·8	18·6	21·0
19	R	19·1	16·2	15·9	16·1	21·9	17·0	14·9	15·8	17·5	17·0
20(2)	N2KNaMg	15·4	19·0	15·6	15·1	19·0	19·5	14·8	13·7	14·6	—

(1) Treatments in alternate years.
(2) Means of two years only per cycle.

* Nitrate of soda.
† Applied in autumn.

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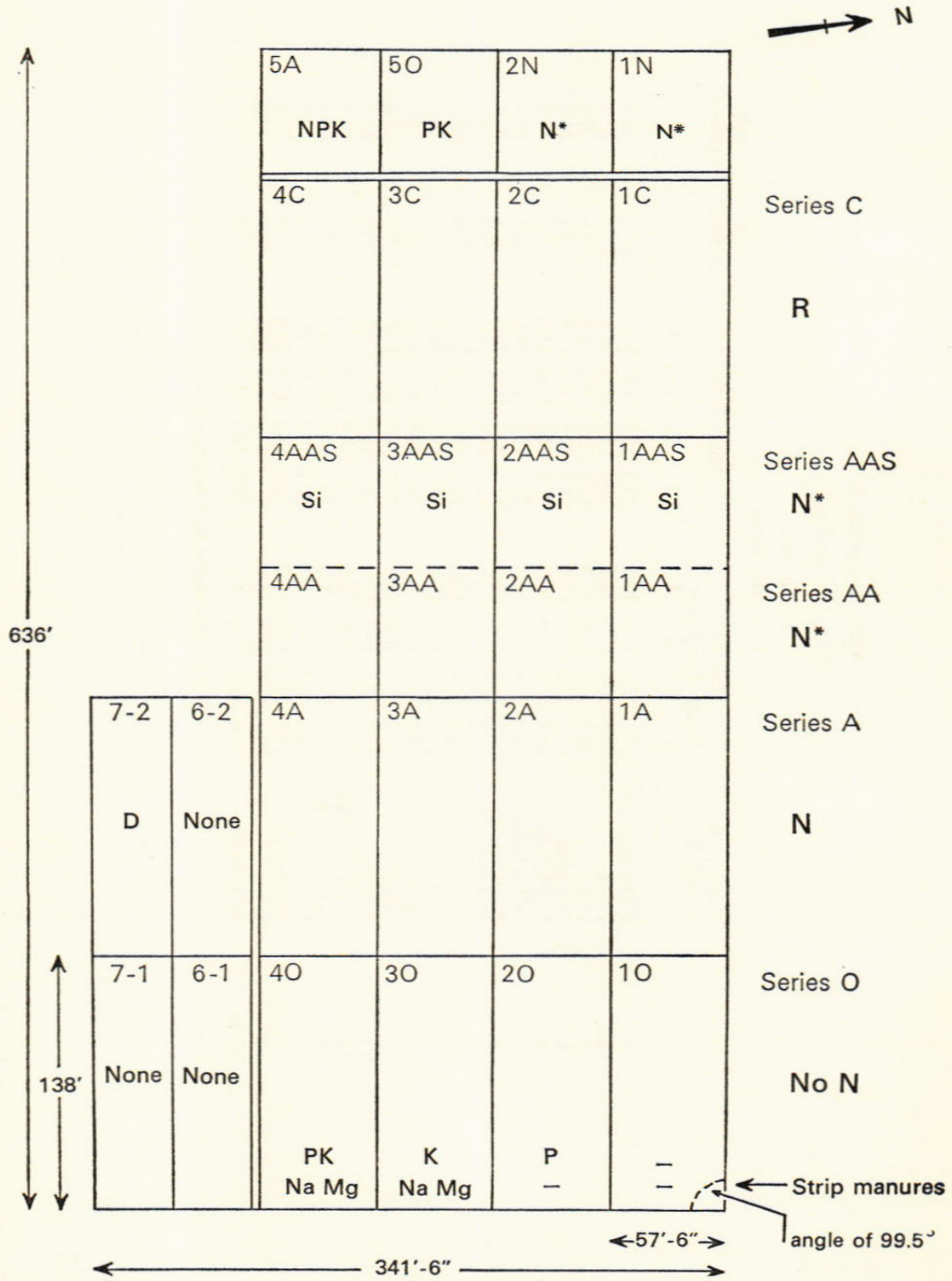
HOOSFIELD _ BARLEY 1852 ONWARDS



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