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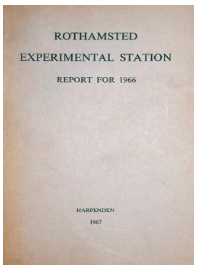

Hoosfield Continuous Barley

R. G. Warren and A. E. Johnson

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HOOSFIELD CONTINUOUS BARLEY

R. G. WARREN and A. E. JOHNSTON

The Classical barley experiment on a 2½-acre site in Hoosfield was started by Lawes and Gilbert in 1852. The design of the main part of the experiment is similar to Barnfield. There are four Strips (1–4) with mineral manures (O, P, KNaMg, PKNaMg), and across these are Series treatments with nitrogen, none (O), ammonium sulphate (A), sodium nitrate (AA), sodium nitrate + sodium silicate (AAS) and rape cake (C) (now castor meal). Beyond the west end of the Strips are four plots, 1/N, 2/N (N as sodium nitrate), 5/O (PK fertilisers) and 5/A (NPK, N as ammonium sulphate). Two other plots, 6 and 7, were sited next to the south-east corner of the Strips. Ashes, which were mixed with the fertilisers to assist spreading, were tested on one half of plot 6, the other half was unmanured. Farmyard manure (FYM) was applied on all of plot 7 until 1871, but to only one half since. The AA and AAS plots with their present treatments started in 1868. Tables 1 and 2 give details of the manurial treatments and history of the plots.

Lawes and Gilbert described the results for the early years, 1852–83. In three papers entitled "The Rothamsted Field Experiments on Barley, 1852–1937", Russell and Watson examined the results exhaustively and compared them with those from other experiments with barley at Rothamsted, Woburn and other farms. They discussed the effects of N, P and K fertilisers and FYM on yield, composition and quality of barley grain. Variations in yields in different seasons, the influence of rainfall, sowing-date and the deterioration in yield of barley grown continuously are other subjects they treated fully. Their comprehensive account includes results of specialised studies on the Hoosfield experiment by Fisher, Frew, Hall and Morison, Mackenzie, "Mathetes", Wishart and Mackenzie and Yates and Watson. Hall *et al.*, Dyer, Keen and Haines, Ziemiecka, and Warren used the soils from the plots for various investigations, and Watson studied the effect of nutrient supply on net assimilation rate and leaf area.

As Russell and Watson dealt so thoroughly with results up to 1936, we shall only review work since then.

Recent crops

Only the crops for the most recent years, 1964–66, are discussed in detail here, but Table 3 includes the yields of grain, 10-year means, for 1852–1963 together with full period means for straw for reference. Table 4 gives yields for 1964–66. After the period dealt with by Russell and Watson (1852–1936) several of the ammonium sulphate plots became very acid, with serious effects on the crops from the early 1940s to the early 1950s. To neutralise the acidity and prevent future acidity a liming scheme was introduced in 1954–55 (Table 2).

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HOOSFIELD CONTINUOUS BARLEY

TABLE 1

MANURIAL HISTORY OF THE HOOSFIELD BARLEY PLOTS, 1852–1966

Plot	Treatment	
GAUGE or *STANDARD SERIES* starting 1852 (so called by Lawes and Gilbert)		
6/1	Unmanured	(10 bushels ashes in 1872)
6/2	Ashes	1852–1932 (except 1928–29) none since
7/1	FYM	1852–71 none since
7/2	FYM	
NO NITROGEN GROUP starting 1852		
1/0	Unmanured	
2/0	P	
3/0	K Na Mg	
4/0	P K Na Mg	
5/0	P K	(N also in 1852 only)
AMMONIUM-N GROUP starting 1852		
1/A	N_1	
2/A	N_1P	
3/A	N_1 K Na Mg	
4/A	N_1P K Na Mg	
5/A	N_1P K	(N_2PK in 1880 only)
NITRATE-N GROUP starting 1868		
Previously received ammonium-N 1852–57 at rate N_2: 1858–67 at rate N_1		
1/AA	N_1	
2/AA	N_1P	
3/AA	N_1 K Na Mg	
4/AA	N_1P K Na Mg	
Starting 1864 plots AA were halved, the half next to the C Series received silicates (1862, 1863 only the quarter plot nearest the C Series received silicates).		
1/AAS	N_1 Si	
2/AAS	N_1P Si	
3/AAS	N_1 K Na Mg Si	
4/AAS	N_1P K Na Mg Si	
Starting 1853, manured in 1852 with PK		
1/N	N_1	
2/N	N_2 1853–57	N_1 1858–1966
CASTOR MEAL GROUP starting 1852		
1/C	C	
2/C	P C	
3/C	K Na Mg C	
4/C	P K Na Mg C	

Plot M The triangular piece of ground to the West of plots 5/O 2/N 1/N received P Na Mg 1855–93 and plot then abandoned because of weeds.

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TABLE 2

DETAILS OF MANURES, CULTIVATIONS AND CROPPING, HOOSFIELD BARLEY, 1852–1966

Fertilisers and FYM applied annually.

Rates per acre*

NITROGEN

Ammonium sulphate at 210, 420 lb. These rates (N_1, N_2) supplied 43 and 86 lb N.

Before 1917 a mixture of equal weights of ammonium sulphate and ammonium chloride was used (except 1887, ammonium sulphate only). In 1901 the mixed salts were compared with ammonium bicarbonate on half of plots 1/A, 2/A, 3/A, 4/A.

Sodium nitrate at 275, 550 lb. These rates (N_1, N_2) supplied 43 lb and 86 lb N.

1964–66 N_2 rate given to Maris Badger, N_1 as usual to Plumage Archer.

PHOSPHORUS

Superphosphate containing 29–30 lb P, 66–69 lb P_2O_5 (366 lb 18·5% P_2O_5 superphosphate).

From 1852 to 1887 superphosphate was made on the Farm from 200 lb calcined bone dust and 150 lb sulphuric acid (sp. gr. 1·7). From 1888 it was supplied ready made and the weight adjusted to give the same amount of phosphorus as in the first period. 1898–1902 basic slag (400 lb) used instead of superphosphate.

POTASSIUM

Potassium sulphate *1852–1857* 300 lb containing 120 lb K (145 lb K_2O)
1858–1966 200 lb containing 80 lb K (96 lb K_2O)

Potassium dressings omitted 1917, 1918.

SODIUM

Sodium sulphate *1852–1857* 200 lb containing 28 lb Na
1858–1966 100 lb containing 14 lb Na

MAGNESIUM

Magnesium sulphate 100 lb containing 10 lb Mg

Magnesium dressings omitted 1917, 1918.

SODIUM SILICATE

1862–1867 200 lb sodium silicate + 200 lb calcium silicate
1868–1966 400 lb sodium silicate

Analyses of sodium silicate: the chemical composition of the mixed silicates is not known, the sodium silicate used since 1904 was a water-soluble powder with a weight ratio $SiO_2 : Na_2O$ of approximately 3.

FARMYARD MANURE

14 tons

ASHES

1852–1916 20 bushels of the clay and weed-ashes as used to mix with the mineral manures to aid their distribution
1917–1932 sifted ashes from the Laboratory furnace

CASTOR MEAL

1852–1857 2,000 lb rape cake (probably supplied 98 lb N)
1858–1940 1,000 lb rape cake except 1917–20 (none available)
1941–1954 1,000 lb castor meal
1955–1966 weight per acre adjusted for analysis so that total nitrogen applied equalled 43 lb N (1964–66, 86 lb N for Maris Badger)

* Plot Areas. The sizes of the plots were decreased in 1893 when paths between Series were widened and new paths between Strips were made; to maintain the rates of nutrients per acre the manures applied per plot were correspondingly smaller.

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TABLE 2—continued

LIMING

To correct acidity that had developed on plots of strips 3 and 4 including 5/O, 5/A, ground chalk (5 tons $CaCO_3$/acre) was applied in winter 1954–55. To prevent further acidity developing a scheme of quinquennial chalk applications was introduced, the amount based on the acidifying effect of the ammonium sulphate (100 lb $CaCO_3$ for every 14 lb N as ammonium sulphate) and the castor meal (50 lb $CaCO_3$ for every 14 lb N as castor meal). First dressing in spring 1955.

CULTIVATIONS

PLOUGHING AND FERTILISER APPLICATIONS. Previous crop stubble usually shallow ploughed in autumn. 1852–1915 plots again shallow ploughed usually in March *after* fertiliser and FYM applied. Since 1916 FYM applied between September and January and plots then reploughed, tractor ploughing since 1921. Fertilisers then applied usually in March and worked in during seed-bed preparation, discing, spring tining, harrowing. Fertilisers applied by manure distributor since 1917 except N applied by hand. 1898–1902 the N was applied as a topdressing instead of to the seed-bed. Plots usually drilled in March.

WEED CONTROL. Up to 1915 the plots were hand hoed in some years when badly infested with weeds. 1929–32 plots were drilled with 18-in. rows to allow inter-row cultivation. Since 1944 spring spraying used to control weeds, 1944–56 DNOC, since 1957 various selective weedkillers. In 1958, 1959, 1961, stubble sprayed in autumn with 2,4-D to check coltsfoot (*Tussilago farfara*), and in 1962–64 dalapon was used in autumn to attempt to kill perennial grass weeds. To control wild oats (*Avena fatua*) much of the green crop on each plot was cut and carted, leaving only a small area for yield estimates in 1948, 1952, 1954, 1955, while in 1953 the whole field was cut green and the produce removed. In recent years wild oats have been kept in check by hand pulling.

HARVESTING. Plots were originally cut by hand, they were first cut by machine in 1910 and then from 1915 to 1957. Sheaves from each plot were stooked on that plot, carted in a large hessian sheet, stored and then threshed during the winter. Since 1958 plots harvested by combine-harvester, yield estimated by weighing 1 or 2 cuts only, rest cleared as discard.

FALLOWING. All plots were bare fallowed in 1912, 1933, 1943 to help weed control. In 1912 the plots were ploughed and subsoiled in a N–S direction, i.e. across the strips. On each fallowing occasion there were a number of ploughings and many cultivations both landwise and across the plots.

CROPPING

Except when fallowed the plots carried barley each year. (In 1906 and 1929 small areas of each plot grew swedes.) Seed rates varied from $1\frac{3}{4}$ to 3 bushels/acre.

Varieties *1852–1880* Chevalier
1881–1890 Archers Stiff Strawed
1891–1897 Carters Paris Prize
1898–1916 Archers Stiff Strawed except 1902–5 Halletts Pedigree Chevalier
1917–1966 Plumage Archer, 1927–32, except 1928, Spratt Archer also grown, 1964–66 Maris Badger also grown.

In 1908 the seed was treated with formalin and in 1928 with Corvusine. From 1936 seed treated each year with various seed dressings.

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TABLE 3

Hoosfield Barley yields 1852–1963

Plot	Treatment	10-year means (grain, cwt/acre) 1852–61	1862–71	1872–81	1882–91	1892–1901	1902–11	1912–21 (1)	1922–31	1932–41 (2)	1942–51 (3)	1952–61 (4)	Means 1852–1963 Grain (cwt/acre)	Straw (cwt/acre)
No nitrogen group														
1/0	Unmanured	11·4	8·8	6·8	6·2	5·3	5·2	6·5	3·7	6·9	9·3	7·4	7·0	7·9
2/0	P	13·9	11·8	9·0	9·6	7·1	9·3	10·2	6·7	11·6	11·7	10·6	10·1	9·7
3/0	K Na Mg	12·5	10·2	7·8	6·0	4·8	5·5	7·5	3·8	9·0	11·7	7·6	7·8	8·9
4/0	P K Na Mg	15·3	12·4	8·8	8·2	6·6	8·4	10·9	6·4	13·5	15·8	10·9	10·5	11·6
5/0	P K	12·3(*b*)	10·9	7·5	7·4	6·2	6·9	7·3	4·8	10·9	15·0	8·9	8·8	10·0
6/1	Unmanured	12·6	9·6	6·9	7·7	5·6	5·4	8·2	3·4	8·7	10·3	6·9	7·7	8·7
6/2	Unmanured	12·1	10·2	7·7	8·2	6·1	7·1	9·9	4·4	8·9	9·8	8·7	8·4	9·3
7/1	Unmanured (after FYM till 1871)			17·4	13·0	10·6	9·7	11·0	7·0	13·4	15·1	11·7	12·0	13·6
Ammonium-N group														
1/A	N	17·0	15·8	13·2	12·0	8·8	10·7	11·2	5·4	10·4	11·5	10·8	11·5	13·1
2/A	N P	22·9	24·7	20·4	18·0	15·5	16·1	16·2	11·8	18·8	15·9	16·8	17·9	19·4
3/A	N K Na Mg	17·8	17·8	15·0	12·4	11·8	11·0	11·3	6·0	13·2	14·4	13·4	13·1	15·8
4/A	N P K Na Mg	23·2	23·8	20·9	20·0	18·0	20·1	18·2	13·1	20·9	17·8	18·9	19·6	22·3
5/A	N P K	21·7	23·1	19·8	15·0	14·1	15·2	16·1	10·9	19·5	14·2	19·8(*c*)	17·3	21·9
Nitrate-N group (*a*)														
1/AA	N		16·0	14·2	14·0	11·6	12·6	12·3	7·1	12·1	13·0	12·9	12·3	15·5
1/AAS	N Si		18·7	17·7	17·1	16·0	14·9	14·9	8·6	16·4	16·1	17·0	15·5	18·3
2/AA	N P		24·0	21·1	21·0	19·4	20·3	19·7	14·7	22·0	18·5	20·2	19·8	22·5
2/AAS	N P Si		24·6	22·3	22·2	20·3	19·5	19·7	14·9	21·4	20·4	22·9	20·6	23·4
3/AA	N K Na Mg		16·5	15·1	14·2	12·8	11·6	12·1	6·3	14·4	15·9	13·9	13·0	16·8
3/AAS	N K Na Mg Si		21·5	19·4	17·5	16·7	15·5	14·2	8·4	16·7	17·3	18·3	16·3	19·8
4/AA	N P K Na Mg		24·0	21·6	20·1	18·5	19·8	18·9	13·3	21·8	21·4	19·9	19·7	22·8
4/AAS	N P K Na Mg Si		25·5	23·6	22·1	20·2	21·4	17·9	14·1	23·1	22·5	23·3	21·2	24·6
1/N	N	19·0	18·8	15·6	15·6	14·1	13·5	11·5	6·2	14·1	14·6	12·1	14·0	17·2
2/N	N	18·0	20·5	17·9	17·0	16·8	16·8	14·8	9·4	17·5	18·1	15·9	16·5	19·5
Organic-N group														
1/C	C	23·4	22·5	19·8	17·5	16·0	17·5	13·5	11·4	18·4	15·6	17·2	17·6	19·9
2/C	C P	23·9	23·7	21·2	19·1	17·1	18·3	14·6	14·8	21·3	20·9	19·5	19·5	21·3
3/C	C K Na Mg	22·1	22·4	19·0	16·8	15·1	17·4	12·2	10·0	17·6	21·1	17·0	17·4	20·0
4/C	C P K Na Mg	23·8	24·4	21·3	17·8	16·6	19·9	13·0	14·0	21·6	23·7	20·0	19·7	22·3
7/2	FYM	22·7	26·7	25·7	23·7	22·9	23·6	18·6	15·0	26·1	26·7	28·0	23·7	28·6

(1) Omitting 1912. (2) Omitting 1933. (3) Omitting 1943. (4) Omitting 1953.
(*a*) Started 1868, except 1/N, 2/N, yields from 1853 1/N, 1858, 2/N. (*b*) Omitting 1852. (*c*) Omitting 1954.

TABLE 4

Yield of Plumage Archer (PA) and Maris Badger (MB) Hoosfield Barley

cwt/acre, mean 1964–66

Plot	Treatment	Grain PA	Grain MB	Straw PA	Straw MB
No Nitrogen group					
1/0	Unmanured	8·2	8·3	4·6	3·2
2/0	P	11·3	11·1	5·9	4·4
3/0	K Na Mg	8·2	7·5	4·6	3·5
4/0	P K Na Mg	12·4	9·4	6·9	3·8
5/0	P K	11·6	9·3	7·2	5·7
6/1	Unmanured	7·2	5·7	4·3	2·7
6/2	Unmanured	9·9	7·2	5·3	4·1
7/1	Unmanured	13·3	8·6	8·7	5·4
Ammonium-N group					
1/A	N	12·2	14·5	8·8	9·1
2/A	N P	22·4	25·6	15·3	20·3
3/A	N K Na Mg	18·2	26·3	15·2	19·4
4/A	N P K Na Mg	26·8	39·8	18·4	28·4
5/A	N P K	30·0	38·2	24·0	32·6
Nitrate-N group					
1/AA	N	12·2	13·0	9·7	11·6
1/AAS	N Si	20·4	20·2	17·5	17·3
2/AA	N P	25·6	32·3	20·4	28·8
2/AAS	N P Si	26·4	30·2	20·4	24·8
3/AA	N K Na Mg	15·5	21·2	15·0	18·4
3/AAS	N K Na Mg Si	21·1	32·0	18·2	25·4
4/AA	N P K Na Mg	26·0	38·7	20·6	36·9
4/AAS	N P K Na Mg Si	29·6	39·3	23·3	34·5
1/N	N	10·5	8·2	12·0	14·4
2/N	N	17·8	23·6	13·4	18·7
Organic-N group					
1/C	C	22·7	34·2	15·6	21·3
2/C	C P	25·5	38·6	16·7	25·1
3/C	C K Na Mg	23·5	36·6	15·6	23·8
4/C	C P K Na Mg	27·6	38·7	19·4	27·3
7/2	FYM	36·6	39·8	28·6	30·7

A change from the old variety, Plumage Archer, to a more productive one was thought desirable, and in 1964 the plots were halved to compare Plumage Archer and Maris Badger. The amounts of N applied, including castor meal, were increased from 43 to 86 lb N/acre for Maris Badger, but otherwise the manuring was unchanged.

In 1964–66 the yields of Plumage Archer were exceptionally good, even when compared with 1932–41, one of the best 10-year periods (Table 5). The NPK plots gave 4–6 cwt more grain/acre and the FYM plot 10·5 cwt more, but the plots without nitrogen yielded about the average for 1932–41.

Table 6 shows that Maris Badger, with more fertiliser N, yielded 10–13 cwt grain/acre more on the NPK plots than Plumage Archer, but only 3 cwt more on the FYM plot, where both varieties received the same amount of manure.

Maris Badger yielded less than Plumage Archer on plots not given nitrogen (Series O) and on plot 7/1, which contains residues from the FYM applied during 1852–71. After 1871 yields on plot 7/1 soon diminished, but Russell and Watson reported that, even after 65 years, it still yielded 3–5 cwt grain/acre more than a plot unmanured since the

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TABLE 5

Yield of Plumage Archer, Hoosfield Barley

Grain, cwt/acre

	1932–41 mean	1964–66 mean
Plots with NPK		
4/A	20·9	26·8
4/AA	21·8	26·0
4/AAS	23·1	29·6
Plot with FYM		
7/2	26·1	36·6
Plots without N		
1/0	6·9	8·2
2/0	11·6	11·3
3/0	9·0	8·2
4/0	12·5	12·4

experiment began. They could offer no explanation of this long-lasting effect of FYM residues. Warren showed that the soil of plot 7/1 contained (in 1946) much organic residue from FYM applied last century and that this decomposed very slowly. Of the organic N (1,500 lb/acre) in the residues, only about 10 lb N was mineralised each year. Some 6 lb entered the crop; the rest probably mineralised too late to be used by barley and was lost from the soil in drainage water. The FYM residues also contained available P and K, and Warren concluded that FYM had such an enduring effect because mineral N is released so slowly from the residues, which also contain available P and K.

Table 7 shows that these residues increased the yield of Plumage Archer but not of Maris Badger in 1964–66. There is no true control for plot 7/1 because it contains small residues of readily soluble PK from the FYM, but Table 8 shows that the amounts are small and nearer those in plot 1/O than plot 4/O. On plot 7/1 Plumage Archer took up more NPK than on 1/O and 4/O, but Maris Badger did not, probably because N was lacking. Tables 7 and 8 show that Maris Badger on the Exhaustion Land, where amounts of PK residues are the same as on Hoosfield (7/1), used the extra P and K and produced more grain and straw when given enough fertiliser N. The mineralised N from the FYM residues is probably

TABLE 6

Difference in yield between Maris Badger (MB) and Plumage Archer (PA), Hoosfield Barley

Grain, cwt/acre, mean 1964–66

	Series				
Strip	0	A	AA	AAS	C
1	0·1	2·3	0·8	−0·2	11·5
2	−0·2	3·2	6·7	3·8	13·1
3	−0·7	8·1	5·7	10·9	13·1
4	−3·0	13·0	12·7	9·7	11·1

Plots

6/1	6/2	7/1	7/2	1/N	2/N	5/O	5/A
−1·5	−2·7	−4·7	3·2	2·3	5·8	2·3	8·2

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TABLE 7

Effect of old residues of FYM on yield and composition of barley

Grain and straw, cwt/acre; NPK, lb/acre

Hoosfield Barley, mean 1964–66

Plot Manuring	1/0 none	4/0 PKNaMg	7/1 FYM 1852–71	7/1 excess over 1/0	7/1 excess over 4/0
Plumage Archer					
Grain	8·2	12·4	13·3	5·1	0·9
Straw	4·6	6·9	8·7	4·1	1·8
In crop					
N	13·2	18·3	21·6	8·4	3·3
P	2·6	5·3	4·9	2·3	−0·4
K	6·1	13·5	14·2	8·1	0·7
Maris Badger					
Grain	8·3	9·4	8·6	0·3	−0·8
Straw	3·2	3·8	5·4	0·6	1·6
In crop					
N	14·6	13·1	13·0	−1·6	−0·1
P	2·8	4·1	3·1	0·3	−1·0
K	6·3	9·2	7·8	1·5	−1·4

Exhaustion Land, mean 1964–66

Plot Manuring 1876–1901	1 none	3 FYM	3 excess over 1
1964–66	78 lb N/acre/year		
Maris Badger			
Grain	13·2	34·2	21·0
Straw	14·0	26·0	12·0

TABLE 8

Effect of old residues of FYM on readily soluble P and K in soil

Experiment	Hoosfield			Exhaustion Land	
Plot	1/0	4/0	7/1	1	3
Manuring	None	PKNaMg	FYM 1852–71	None	FYM 1876–1901
P soluble in 0·5*M*-$NaHCO_3$ mg/100 g					
	0·5	12·6	1·2	0·4	1·6
K soluble in 1*N*-ammonium acetate mg/100 g					
	8·7	43·3	12·1	8·6	11·6

produced too late in the season for Maris Badger, and this also restricts the uptake of P and K.

The failure of Maris Badger to measure the available nutrients from the FYM residues is relevant to the immediate future of plot 7/1. No information will be obtained from the plot when the new variety of barley is grown. The plot could be omitted from the experiment and used to study the residues in detail. Kale and sugar beet would probably make more use of the N released later from the residues, and it would be interesting to see whether adding an energy source to the soil would increase the mineralisation of the organic nitrogen.

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Maris Badger, a stiffer-strawed variety than Plumage Archer, is better suited for larger amounts of fertiliser N. Table 4 shows that, given PK also, 86 lb fertiliser N/acre increased its yield by 30 cwt grain/acre, Plumage Archer increased its yield by only 15 cwt when given 43 lb N/acre. Table 9 shows the increases from P and K fertiliser. Because the amounts of

TABLE 9

Increase in barley yield from PK fertilisers

Means of A and AA series, Hoosfield Barley
grain, cwt/acre, mean 1964–66

	Plumage Archer (43 lb N/acre)	Maris Badger (86 lb N/acre)
Increase from		
P (in presence of K)	9·6	15·5
K (in presence of P)	2·4	10·4

fertiliser N differed, the figures do not give a quantitative comparison of the responsiveness of the two varieties to P and K, but it seems that Maris Badger used fertiliser K more effectively for producing grain. With the same quantity of fertiliser K and twice the fertiliser N the increase in Maris Badger from K fertiliser was four times greater than in Plumage Archer; for P the difference was only 50%.

Sodium silicate is a treatment of special interest in the Hoosfield experiment. In 1964–66 its effect on yield was shown most convincingly by Maris Badger. Table 10 compares the yields of the two varieties with sodium nitrate alone (Series AA) and with sodium silicate (AAS).

TABLE 10

Effect of sodium silicate, Hoosfield Barley

(Maris Badger (MB) Plumage Archer (PA))
grain, cwt/acre, mean 1964–66

		Series					
		AA (sodium nitrate)		AAS (sodium nitrate + sodium silicate)		Increase from sodium silicate	
Strip	Fertiliser	MB	PA	MB	PA	MB	PA
1	0	13·0	12·2	20·2	20·4	7·2	8·2
2	P	32·3	25·6	30·2	26·4	−2·1	0·8
3	K Na Mg	21·2	15·5	32·0	21·1	10·8	5·6
4	P K Na Mg	38·7	26·0	39·3	29·6	0·6	3·6

Yield of Maris Badger was increased greatly by silicate only where superphosphate was not given, and this interaction was less evident with Plumage Archer. To account for the effect of sodium silicate, Lawes and Gilbert suggested that it made some of the phosphorus locked up in the soil available to barley. However, Hall and Morison decided that the action of the silicate was on the plant, not the soil, and that the silicate facilitates the uptake of phosphorus. Fisher examined further plant analyses for P and supported Lawes and Gilbert in concluding that the silicate acted on the soil to make more phosphorus available, but proof based on soil analyses was still lacking.

Table 11 shows the percentage of P and the total content of the two varieties in 1964 and 1966. Little or no effect is expected from silicate on

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TABLE 11

Effect of sodium silicate on the phosphorus percentage and content, Plumage Archer and Maris Badger, Hoosfield Barley

% P in grain dry matter, 1964 and 1966

Plumage Archer

Strip	Manuring	AA 1964	AA 1966	AAS 1964	AAS 1966	Increase from silicate 1964	Increase from silicate 1966
1	None	0·328	0·310	0·375	0·356	0·047	0·046
2	P	0·408	0·372	0·407	0·371	−0·001	−0·001
3	K Na Mg	0·333	0·306	0·369	0·360	0·036	0·054
4	P K Na Mg	0·382	0·383	0·392	0·404	0·010	0·009
	Maris Badger						
1	None	0·304	0·266	0·314	0·329	0·010	0·063
2	P	0·385	0·414	0·386	0·390	0·001	−0·024
3	K Na Mg	0·288	0·258	0·335	0·366	0·047	0·108
4	P K Na Mg	0·404	0·381	0·408	0·401	0·004	0·020

P content of crop, mean of 1964 and 1966
lb element/acre

PA — Plumage Archer
MB — Maris Badger

Strip	Manuring	AA PA	AA MB	AAS PA	AAS MB	Increase from silicate PA	Increase from silicate MB
1	None	3·9	4·2	7·9	7·2	4·0	3·0
2	P	10·6	14·4	11·8	13·2	1·2	−1·2
3	K Na Mg	5·1	6·0	7·8	11·6	2·7	5·6
4	P K Na Mg	10·0	17·2	12·6	18·3	2·6	1·1

plots given superphosphate each year. For the plots without superphosphate, the two results, (1) extra yield of grain, and (2) the increase in P per cent in the grain, *taken together* provide good evidence that sodium silicate increases the amount of available P, but direct evidence from soil studies is preferred.

N, P, K, Na, Ca, Mg were measured in the 1964 and 1966 crops of both varieties from all plots. Table 12 shows the amounts of the elements removed in the crops from plots of Series O, A, AA, AAS, C on Strip 4 and from 7/2 only. Given the same quantity of FYM (plot 7/2), the two varieties contained almost identical amounts of the elements (mean yields 1964, 1966 were Plumage Archer 36·6; Maris Badger 39·8 cwt grain). Where Plumage Archer received 43 lb N and Maris Badger 86 lb N/acre, the form of nitrogen, ammonium sulphate or sodium nitrate, did not affect the uptakes of N. The recoveries of fertiliser N in the crops were Plumage Archer, 58%; Maris Badger, 69%. Lawes and Gilbert found 40% of the added N was recovered in the crop; Russell and Watson reported values between 1919 and 1923 of 40%, and between 1924 and 1928 of 29%, when yields were also smaller.

Most of the nitrogen in castor meal is mineralised quickly in the soil, and the amount taken up by the crop equals that from ammonium sulphate and sodium nitrate with 43 lb N/acre, but is a little less with 86 lb N. The effect of residues from rape cake measured in the Hoosfield and Barnfield experiments, 1917–21, were small.

On the fertiliser plots Maris Badger, with the extra N, removed about

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TABLE 12

Amounts of N, P, K, Na, Ca, Mg removed in crops of Plumage Archer and Maris Badger, Hoosfield Barley

Grain + straw, mean of 1964 and 1966. lb element/acre

PA, Plumage Archer, 43 lb N/acre/year
MB, Maris Badger, 86 lb N/acre/year

		N		P		K	
Plot	Treatment	PA 43 lb N	MB 86 lb N	PA	MB	PA	MB
4/0	P K Na Mg	18·3	15·1	5·3	4·1	13·5	9·2
4/A	NH_4–N P K Na Mg	44·3	73·8	11·2	17·5	30·4	49·4
4/AA	NO_3–N P K Na Mg	42·2	74·5	10·0	17·2	28·0	47·4
4/AAS	NO_3–N P K Na Mg Si	47·1	72·8	12·6	18·3	34·7	53·2
4/C	Org–N P K Na Mg	43·7	68·4	11·8	18·4	32·2	48·7
7/2	FYM	67·8	70·1	17·6	18·3	61·0	58·7
		Na		Ca		Mg	
4/0	P K Na Mg	0·5	0·3	2·4	1·5	1·8	1·4
4/A	NH_4–N P K Na Mg	1·2	1·5	6·3	10·2	3·9	6·2
4/AA	NO_3–N P K Na Mg	2·3	5·1	5·5	10·6	3·4	6·0
4/AAS	NO_3–N P K Na Mg Si	4·3	9·9	7·1	12·0	4·6	6·8
4/C	Org–N P K Na Mg	1·1	1·6	5·8	9·4	4·1	6·8
7/2	FYM	2·2	1·7	10·0	10·0	5·5	6·0

6 lb more P and 19 lb more K per acre than Plumage Archer. The figures for the other elements are: Na 3–6 lb, where sodium nitrate and sodium silicate were given (but none otherwise), Mg 2 lb, Ca 5 lb. The uptakes of Na from sodium nitrate and sodium silicate were small, and the Na in them (74 and 60 lb/acre respectively) did not significantly lessen the uptake of K, which is in accord with the results of Barnfield and Park Grass.

The soil

The soils at Rothamsted are mainly derived from "Clay-with-Flints" which overlies chalk at various depths. The soil carrying the barley experiment on Hoosfield belongs to the Batcombe Series (undifferentiated) as classified by the Soil Survey of England and Wales. The field is on a level plateau where the "Clay-with-Flints" is thick and the soil has a flinty silt loam or loam surface. Like several of our other old arable fields, Hoosfield was given a large dressing of chalk in the early part of the last century, when the practice was to dig out the underlying chalk and spread it on the arable land. Detailed surveys for pH and $CaCO_3$ of Broadbalk and Hoosfield, made around 1954, suggested that these early large dressings were not applied uniformly, confirming, for Hoosfield, Russell and Watson's surmise from a few measurements of pH made in 1932.

The amount applied lessened with increased distance from one side or corner of the field, so that some parts had 10–15 tons more chalk per acre than others. This difference would not affect the yield of crops in the early years, but parts of the field with the smallest reserves of $CaCO_3$ to replace calcium lost in drainage water and removed in crops would become acid soonest. The onset of acidity would be hastened by ammonium sulphate and to a lesser extent by rape cake or castor meal. Table 13 shows the $CaCO_3$ contents of soils of the plots of the Barley experiment in 1946, and

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indicates that the early chalking was not uniform. Most $CaCO_3$ (0·8–1·7%) was within the O, A, AA and AAS Series of Strips 1 and 2. Beyond this in the direction of the C Series and towards Strips 3 and 4 $CaCO_3$ content diminishes abruptly. More detailed soil sampling and analysis done in the

TABLE 13

Percentage $CaCO_3$ in surface soils, 0–9 in., Hoosfield Barley, 1946

						Series
		(*5/A*)0·04	(*5/0*)0·08	(*2/N*)0·10	(*1/N*)0·09	
		0·01	0·00	0·04	0·17	C
		0·16	0·34	1·17	0·80	AAS
		0·17	0·38	1·70	1·48	AA
(*7/2*)0·48	(*6/2*)0·07	0·00	0·06	1·11	1·34	A
(*7/1*)0·14	(*6·1*)0·08	0·20	0·14	1·02	1·55	0
	Strip	4	3	2	1	

1950s showed that sharp changes did not coincide with the boundaries between Series C and AAS and between Strips 2 and 3, ammonium sulphate and castor meal had, as expected, increased the irregularities. In 1946 the centres of plots 3/A, 4/A and 5/A (all receiving ammonium sulphate) were already acid.

A second irregularity in the soils has come about since the experiment began by movement of soil across plot boundaries during cultivations. More such movement on Hoosfield than on the other Classical experiments probably reflects the intensive cultivations given during the early fallows before weeds could be controlled with chemicals. Cultivations were done both along and across the plots. That much soil had moved in this way became apparent in 1949, when the crop in the centres only of three of the five ammonium sulphate plots (3/A, 4/A, 5/A) were poor and discoloured from acute soil acidity. Crops were normal on the other two plots given ammonium sulphate (1/A, 2/A), where there were reserves of $CaCO_3$. In the early 1950s soil samples were taken, closely spaced (about 1 ft), in lines across the plots of the O and A series and several other plots to measure the extent of soil movement. Table 14 shows the changes in pH and total P across an ammonium sulphate plot (4/A). There were

TABLE 14

Change in pH and Total P across Plot 4/A Hoosfield Barley, 1954

Surface soils 0–6 in.

	Path	Plot 4/A										Path
pH (in water)	7·0	6·0	5·4	5·1	4·9	4·8	4·9	5·1	5·8	6·9	7·5	7·7
Total P mg/ 100 g	88	110	118	122	125	126	125	120	110	90	70	63

about 50 samples across each plot, and the results of analysis when plotted gave surprisingly smooth curves. For ease of presentation the results are condensed to 12 values for each kind of analysis. The paths between the strip treatments are fortunately wide, about $5\frac{1}{4}$ ft (8 links); they are cultivated but uncropped and unmanured since 1893. The figures for pH show that some of the slightly calcareous soil of the paths has been drawn into the plot. We cannot be sure that the centre has not been disturbed,

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but if it has the amount is likely to be small, because the pH over the central third of the plot changes little (0·2 pH unit). The figures for total P suggest the same amount of soil movement as do the pH values. Much P has been taken from the outside thirds of the plot into the paths (P contents of the undisturbed paths should be 40–50 mg P/100 g). Also, soil analysis showed extra P for a distance of several yards into the no P plots (6/2, 3/A) on either side of 4/A. The other plots examined showed approximately the same amount of soil movement. It must be stressed here that, for many years now, precautions have been taken to minimise the carry-over of soil; cross cultivations are avoided where possible, and ploughing is done so that the soil is turned in opposite ways on successive occasions. The results in Table 14 suggest that satisfactory soil samples could be obtained from the central third of the plot, that is by discarding 7 yd on each side and at the ends of the plots. When the 1946 soil samples were taken a surround of about 5 yd was discarded; the analyses of these samples are therefore probably subject to errors of a few per cent.

Because of the acute acidity on some of the ammonium sulphate plots

TABLE 15

Soil reaction and organic carbon and nitrogen content of Hoosfield Barley soils, 1965

Surface soils 0–9 in.

Plot	Treatment	pH in water	Organic carbon (%)	Total N (%)
No nitrogen group				
1/0	Unmanured	7·9	0·81	0·101
2/0	P	7·8	0·82	0·097
3/0	K Na Mg	7·8	0·91	0·107
4/0	P K Na Mg	7·2	0·97	0·110
5/0	P K	7·1	0·96	0·108
6/1	Unmanured	6·1	0·97	0·111
6/2	Unmanured	6·2	0·96	0·109
7/1	Unmanured	6·6	1·32	0·139
Ammonium-N group				
1/A	N	8·0	0·86	0·108
2/A	N P	7·7	0·90	0·107
3/A	N K Na Mg	7·5	0·90	0·106
4/A	N P K Na Mg	6·7	0·90	0·100
5/A	N P K	6·2	1·03	0·113
Nitrate-N group				
1/AA	N	8·1	0·92	0·110
1/AAS	N Si	8·1	0·91	0·108
2/AA	N P	7·9	1·01	0·114
2/AAS	N P Si	7·9	0·98	0·110
3/AA	N K Na Mg	8·0	0·93	0·108
3/AAS	N K Na Mg Si	8·1	0·89	0·102
4/AA	N P K Na Mg	7·5	1·02	0·109
4/AAS	N P K Na Mg Si	7·5	0·90	0·101
1/N	N	6·8	1·02	0·115
2/N	N	7·8	1·03	0·117
Organic-N group				
1/C	C	6·9	1·17	0·129
2/C	C P	6·5	1·10	0·117
3/C	C K Na Mg	7·1	1·08	0·114
4/C	C P K Na Mg	6·9	1·10	0·118
7/2	FYM	7·8	3·37	0·304

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and slight acidity elsewhere, a scheme of liming was introduced. In the winter 1954–55, 5 tons chalk/acre were applied to Strips 3 and 4, including plots 5/A and 5/O. Regular chalk supplements were prescribed for all plots receiving ammonium sulphate or castor meal; these were 100 lb $CaCO_3$/14 lb N as ammonium sulphate and 50 lb $CaCO_3$/14 lb N as castor meal. Ten years later in 1965 the soil reaction of the chalked plots was still satisfactory, except plot 5/A (pH 6·2). Table 15 shows the pH values for all plots in 1965. Plot 5/A requires an extra dressing of chalk, and several other plots (e.g. 6/1, 6/2, 7/1), which did not need liming when the 1954–55 scheme began, are now slightly acid. It is therefore time to start a new scheme for liming at regular intervals.

Surface soil samples, 0–9 in., were taken in 1965 from within the least disturbed area at the centre of the plot. Tables 15, 16 and 17 show pH, content of organic carbon and total N, and the amounts of soluble P (by four methods), soluble K (three methods) and soluble Na (one method). Total P was not determined.

TABLE 16

Readily soluble phosphorus in the surface soils, Hoosfield Barley, 1965

		P soluble in			
Plot	Treatment	0·01*M*-$CaCl_2$ (g mols/litre × 10^{-6})	0·5*M*-$NaHCO_3$ (mg/100 g)	0·3*N*-HCl (mg/100 g)	Acetic acid–sodium acetate pH 4·8 (mg/100 g)
No nitrogen group					
1/0	Unmanured	0·2	0·5	0·6	0·2
2/0	P	5·4	7·8	39·4	16·6
3/0	K Na Mg	0·3	0·9	1·1	0·2
4/0	P K Na Mg	21·2	12·6	38·1	8·6
5/0	P K	18·4	12·8	27·5	5·5
6/1	Unmanured	0·3	0·6	0·3	0·1
6/2	Unmanured	0·3	0·7	0·6	0·1
7/1	Unmanured	0·4	1·2	1·1	0·2
Ammonium-N group					
1/A	N	0·2	0·4	0·6	0·2
2/A	N P	6·2	8·2	44·0	15·3
3/A	N K Na Mg	0·2	0·4	0·2	0·1
4/A	N P K Na Mg	14·4	10·3	24·3	3·6
5/A	N P K	11·4	11·9	21·6	2·5
Nitrate-N group					
1/AA	N	0·2	0·4	0·7	0·2
1/AAS	N Si	0·2	0·4	1·1	0·4
2/AA	N P	6·2	8·6	41·6	14·6
2/AAS	N P Si	4·5	5·9	47·4	19·2
3/AA	N K Na Mg	0·1	0·4	0·7	0·2
3/AAS	N K Na Mg Si	0·4	0·4	1·0	0·3
4/AA	N P K Na Mg	19·1	11·0	29·8	7·8
4/AAS	N P K Na Mg Si	11·4	7·2	34·1	12·5
1/N	N	0·2	0·5	0·5	0·1
2/N	N	0·3	1·3	1·1	0·2
Organic-N group					
1/C	C	0·4	1·5	1·1	0·3
2/C	C P	24·6	11·7	34·5	4·9
3/C	C K Na Mg	1·0	1·9	1·6	0·4
4/C	C P K Na Mg	22·0	11·5	32·8	5·5
7/2	FYM	25·4	10·2	33·3	15·0

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TABLE 17

Readily soluble potassium and sodium in the surface soils, Hoosfield Barley, 1965

Plot	Treatment	K mg/100 g soluble in 1*N*-ammonium acetate	K mg/100 g soluble in 0·01*M*-$CaCl_2$	K mg/100 g soluble in 0·3*N*-HCl	Na mg/100 g soluble in 1*N*-ammonium acetate
No nitrogen group					
1/0	Unmanured	8·7	1·1	5·7	5·1
2/0	P	7·1	0·8	4·4	4·7
3/0	K Na Mg	49·6	16·1	38·8	5·1
4/0	P K Na Mg	43·3	14·3	35·4	4·5
5/0	P K	42·4	13·9	34·7	4·6
6/1	Unmanured	10·1	1·9	6·3	4·2
6/2	Unmanured	8·8	1·6	5·5	4·1
7/1	Unmanured	12·1	2·0	7·4	4·8
Ammonium-N group					
1/A	N	7·2	1·0	4·8	7·3
2/A	N P	6·2	0·7	3·9	6·0
3/A	N K Na Mg	43·0	14·9	34·3	5·3
4/A	N P K Na Mg	36·2	12·1	29·4	6·9
5/A	N P K	40·6	11·6	31·8	3·8
Nitrate-N group					
1/AA	N	6·8	0·9	4·6	9·4
1/AAS	N Si	7·0	0·7	4·3	17·1
2/AA	N P	6·7	0·8	4·1	10·1
2/AAS	N P Si	6·3	0·6	3·6	15·5
3/AA	N K Na Mg	45·8	14·0	35·9	12·3
3/AAS	N K Na Mg Si	44·4	14·8	34·6	10.2
4/AA	N P K Na Mg	41·0	14·7	34·2	15·2
4/AAS	N P K Na Mg Si	35·8	12·4	31·8	16·0
1/N	N	7·1	1·1	4·5	16·4
2/N	N	8·4	1·2	4·9	13·1
Organic-N group					
1/C	C	10·2	1·9	6·6	4·8
2/C	C P	8·3	1·5	5·3	4·9
3/C	C K Na Mg	41·4	14·9	34·6	4·0
4/C	C P K Na Mg	38·4	12·3	36·2	11·1
7/2	FYM	75·8	28·8	60·5	5·2

Total N and organic matter. Table 15 shows the N content of the unmanured plot is the same as for many years past at about 0·10% N, and the NPK fertiliser plots contain the usual small extra amount (0·01% N). The N in the FYM plot (7/2), however, increased during the past 20 years more than was expected (total N in 1946, 0·27%; 1965, 0·30%), probably because the extra cultivations in the early 1930s and the intensive cultivations during the fallow year, 1933, oxidised more organic matter than when the field is cropped. A similar extra loss was noted on Broadbalk after the fallowing scheme was introduced in 1926. The organic residues from FYM applied last century on plot 7/1 continue to decrease slowly: between 1946 and 1965 the mean annual rate of loss of N was the same as between 1913 and 1946. There is a similar slow decomposition on the old FYM plots of the Exhaustion Land.

Potassium and sodium (Table 17). The potassium analyses show the expected effects, large accumulations from K fertilisers, much larger from

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FYM and little or none from castor meal. Table 18 shows the amounts of K soluble in *N*-ammonium acetate for the Series treatments O, A, AA, AAS and Strips 1–4. As was found by analysis of the Barnfield soils, the

TABLE 18

Effect of sodium on the readily soluble K in the surface soils, Hoosfield Barley, 1965

K soluble in 1*N*-ammonium acetate, mg/100 g

			Series			
			O	A	AA	AAS
		N as		$(NH_4)_2SO_4$	$NaNO_3$	$NaNO_3$
					Sodium silicate	
					Without	With
Strip	Treatment	Na lb/acre/year	0	0	74	134
1	Unmanured	0	9	7	7	7
2	P	0	7	6	7	6
3	K Na Mg	14	50	43	46	44
4	P K Na Mg	14	43	36	41	36

Na (74 lb/acre) in sodium nitrate (Series AA) has not conserved soil K any more than has ammonium sulphate (Series A). Even the extra amount of Na in the sodium silicate (60 lb Na/acre) given to Series AAS has not affected removal of soil K. Soil not given K on Hoosfield has only about half the soluble K as corresponding soils on Barnfield. Where K has been applied the amounts of readily soluble K in the soil are much the same, but the greater amount of K given on Barnfield, 200 lb (Hoosfield 80 lb), has either been removed by the crop or fixed in non-exchangeable forms. The plots on both fields given only FYM receive the same amount each year, but the one on Hoosfield now has 50% more soluble K than the one on Barnfield.

As on Barnfield, smaller amounts of Na than K are retained in an exchangeable form in the soil. On Hoosfield the sodium soluble in *N*-ammonium acetate ranges from 4·0 to 17·1 mg/100 g soil. On Barnfield the range is 0·4–5·8 mg/100 g. On both fields the increase on the plot given only FYM is about the same, 0·6 mg/100 g. It is not known why soils on Hoosfield have more exchangeable Na than on Barnfield when Na is added as fertiliser, the root crops on Barnfield may have removed most of the available Na, whereas barley takes up much less.

Phosphorus. Table 16 shows the amounts of soluble P determined by four methods that have been widely used to measure the P status of soils. The soils of the current Classical experiments contain either very small or large amounts of P, so are not suitable for testing empirical methods of analysis used to give advice on phosphate manuring. The larger amounts in the Classical experiments should, however, be an advantage in studies of the effects of manurial treatments and variable soil factors on the phosphate residues in the soil. It is reasonable to suppose that such effects would apply to the soils with small to medium amounts of P on commercial farms, and the information gained from the rich soils would be useful. The analyses for P in the soils of the five Series (O, A, AA, AAS, C) on Strips 1–4 are arranged in Table 19 to show how differences in

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$CaCO_3$ content of the Hoosfield soils affect the amount of soluble P. The $CaCO_3$ content of the soils, shown in Table 13, are used to divide the plots into the two groups used in Table 19. No precise percentages $CaCO_3$ are set as the limits of the two groups, because during the long period phosphate accumulated in the soil the $CaCO_3$ content gradually decreased by losses of Ca. A difference in $CaCO_3$ like the one indicated must have existed between the two groups of plots for many years. The four plots of each Series except C are divided equally between the two groups; all plots of Series C are in the group with little or no $CaCO_3$. As expected, the soluble P in all plots without superphosphate (Strips 1, 3) is so little that the chances of detecting an effect of $CaCO_3$ are negligible. In contrast, there are large effects on soluble P in all plots with superphosphate (Strips 2, 4). With two of the methods of analysis (0·01*M*-$CaCl_2$ and 0·5*M*-$NaHCO_3$), the extra $CaCO_3$ in Strip 2 has decreased the solubility in $CaCl_2$ to one-third and in $NaHCO_3$ to three-quarters. Soluble

TABLE 19

Effect of $CaCO_3$ and sodium silicate on readily soluble P in the surface soils, Hoosfield Barley, 1965

Strip	1	2	3	4
P fertiliser	0	P	0	P
$CaCO_3$	*1–1·5%*		*small or none*	
Series	P soluble in 0·01*M*-$CaCl_2$ g mol P/litre × 10^{-6}			
O	0·2	5·5	0·3	21
A	0·2	6·0	0·2	14
AA without silicate	0·2	6·0	0·1	19
AAS with silicate	0·2	4·5	0·4	11
Mean	0·2	5·5	0·2	16
$CaCO_3$	*small or none*			
C	0·4	25	1	22
	P soluble in 0·5*M*-$NaHCO_3$ mg P/100 g			
O	0·5	7·5	1·0	13
A	0·5	8·0	0·5	10·5
AA without silicate	0·5	8·5	0·1	11
AAS with silicate	0·5	6·0	0·5	7
Mean	0·5	7·5	0·5	10·5
C	1·5	11·5	2·0	11·5
	P soluble in acetic acid-sodium acetate pH 4·8 mg P/100 g			
O	0·2	16·5	0·2	8·5
A	0·2	15·5	0·1	3·5
AA without silicate	0·2	14·5	0·2	8·0
AAS with silicate	0·4	19·0	0·3	12·5
Mean	0·2	16·5	0·2	8·0
C	0·3	5·0	0·4	5·5
	P soluble in 0·3*N*-HCl mg P/100 g			
O	0·5	39	1·0	38
A	0·5	44	0·2	24
AA without silicate	0·5	42	0·5	30
AAS with silicate	1·0	47	1·0	34
Mean	0·5	43	0·7	32
C	1·0	34	1·5	33

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P in the two acid solvents show effects in the opposite direction; twice as much P was dissolved by acetic acid–sodium acetate from soils of Strip 2 and 1·3 times as much by 0·3*N*-HCl. On Series C, because the plots on Strips 2 and 4 both have little or no $CaCO_3$, there is no difference in soluble P by any of the methods. No chemical explanation of these $CaCO_3$ effects can be deduced from these simple tests, but the effects merit further study, especially with respect to: (1) soils with small P residues; (2) the adverse effect of over-liming and irregular distribution of liming materials on P soluble in calcium chloride and sodium bicarbonate; (3) the improvement of simple methods of soil analysis designed to give information on phosphate manuring. One other result of interest in Table 19 is the effect of past acidity on plot 4/A. The change to less-soluble phosphate (in weak acids) during the period of acute acidity has not been fully reversed during the 10 years since chalking in 1954–55. The soluble P in the two acid solvents is appreciably less (acetic acid–sodium acetate, 3·5; 0·3*N*-HCl, 24 mg P/100 g) than for the plots of other Series (O, AA, AAS) on strip 4.

Sodium silicate has increased the yield of barley on the plots without P, but not on those given superphosphate, since it was first applied in 1862. It seems that the silicate increases the availability of the small amount of P in the plots not given any. It is not expected that simple methods for measuring soluble P would detect any change with certainty, but again it is reasonable to expect that the silicate would also react with the larger amounts of P in the superphosphate plots. Soluble P measurements on these would be therefore more rewarding. Any increase in available P on these plots would not alter barley yields, because a generous dressing of superphosphate is given to the crop each year. Table 19 shows the effect of silicate on soluble P, measured by the same four methods used to detect the effect of $CaCO_3$. As was noted on the effect of $CaCO_3$, the methods divide into the same two groups by showing differences in opposite directions for the effect of silicate. With 0·01*M*-$CaCl_2$ and 0·5*M*-$NaHCO_3$, the amounts of soluble P are much less for silicate plots (AAS) than for others (AA). With acid solvents, the soluble P is significantly more for the silicate plots. As with $CaCO_3$, no chemical explanation can be given of the sodium silicate effects from these simple tests, but they do establish that sodium silicate alters the solubility of soil phosphate.

The effects on soluble P by $CaCO_3$ and sodium silicate reported here are not because of differences between the total P content of Strips 2 and 4. Although total P has not been determined recently, the differences were small in 1946 and cannot have changed much since.

Extending the use of the Hoosfield Barley Experiment. Even with the more productive modern variety of barley, the experiment on Hoosfield was not expected to give much new information. Changes have therefore been proposed. Part of the site will have a rotation of different crops, and provision will be made for testing soil sterilants. These changes will allow barley grown continuously to be compared with barley after other crops, and allow losses from soil-borne diseases and pests to be estimated. To improve the continuous-barley section, several different amounts of

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fertiliser N will be tested. The area under a crop rotation includes part of the sodium silicate plots, so that effects on crops other than barley will be forthcoming.

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