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## Exhaustion Land Experiment plan and fertilizer treatments, Phase IV, 1986-2006

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**Description:** Plans and details of the fertilizer treatments applied to the Rothamsted Exhaustion Land Experiment, Phase IV (1986-2006), not to scale.

- **Page 1:** Cover page
- **Page 2:** Experiment overview, 1856-present day
- **Page 3:** Experiment plan Phase IV, 1986-1992, P build up phase
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- Johnston, A. E. , Poulton, P. R. , White, R. P. and Macdonald, A. J. (2016) Determining the longer term decline in plant-available soil phosphorus from short-term measured values, *Soil Use and Management*, **32**, 151-161 DOI: [10.1111/sum.12253](https://doi.org/10.1111/sum.12253)
- Yield books and plans, see <http://www.era.rothamsted.ac.uk/eradoc/books/2>

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## Exhaustion Land Experiment overview

### Phase I

#### Plot numbers 'Smiths Wheat' experiment, 1856-1875

V	IV	III	II	I		V	IV	III	II	I
Nil	Nil	N	NPKNaMg	PKNaMg		Nil	Nil	N	NPKNaMg	PKNaMg

#### Plot numbers Potato experiment, 1876-1901

1	3	5	7	9		2	4	6	8	10
Nil	FYM	N	NPKNaMg	P		Nil	FYM	N*	N*PKNaMg	PKNaMg

### Phase II

←————— Unfertilized 1902-1939 —————→

### Phase III

←————— PK residues (Basal N) 1940-1975 —————→

All main plots divided into 4 sub-plots in 1976 with 4 N rates

←————— PK residues (Rates of N) 1976-1985 —————→

### Phase IV

#### "P Test"

1986-2006

Rates of P (Basal K & N) 1986-92

PK residues (Rates of N) 1986-91

#### "K Test"

K residues (Basal P & N) 1992-2006

No fresh P (Basal K & N) 1993-99

Maintenance P (Basal K & N) 2000- (except P0 plots)

### Phase V

#### "P Test"

2007-

Maintenance P (Basal K & N) 2000- (except P0 plots)

P withheld from residual P plots (P1) since 2016

#### "K Test"

Rates of K (Basal P & N) 2007-

### **Cropping:**

1856-1875 winter wheat; 1876-1901 potatoes.

1902-1991 spring barley most years, fallow in 1920, 1967 & 1975.

1992 onwards winter wheat (except 2001 when w wheat failed so re-sown to spring wheat)

# Exhaustion Land Experiment Plan

1986-1992

Phase IV

P build up phase

↗ N

<b>Plot 10</b> 101 <b>N1</b>	<b>Plot 8</b> 081 <b>N1</b>	<b>Plot 6</b> 061 <b>N1</b>	<b>Plot 4</b> 041 <b>N1</b>	<b>Plot 2</b> 021 <b>N1</b>
102 <b>N0</b>  (PKNaMg) (1876-1901)	082 <b>N0</b>  (N*PKNaMg) (1876-1901)	062 <b>N0</b>  (N*) (1876-1901)	042 <b>N0</b>  (FYM(N*P)) (1876-1901)	022 <b>N0</b>  (Nil (FYM)) (1876-1901)
103 <b>N3</b>	083 <b>N3</b>	063 <b>N3</b>	043 <b>N3</b>	023 <b>N3</b>
104 <b>N2</b>	084 <b>N2</b>	064 <b>N2</b>	044 <b>N2</b>	024 <b>N2</b>
<b>Plot 9</b> 091 <b>P3</b>	<b>Plot 7</b> 071 <b>P3</b>	<b>Plot 5</b> 051 <b>P3</b>	<b>Plot 3</b> 031 <b>P3</b>	<b>Plot 1</b> 011 <b>P3</b>
092 <b>P2</b>  (P) (1876-1901)	072 <b>P2</b>  (NPKNaMg) (1876-1901)	052 <b>P2</b>  (N) (1876-1901)	032 <b>P2</b>  (FYM(P)) (1876-1901)	012 <b>P2</b>  (Nil) (1876-1901)
093 <b>P1</b>	073 <b>P1</b>	053 <b>P1</b>	033 <b>P1</b>	013 <b>P1</b>
094 <b>P0</b>	074 <b>P0</b>	054 <b>P0</b>	034 <b>P0</b>	014 <b>P0</b>

(not to scale)

## Annual Treatments per hectare, 1986-1992:

### "P Test" sub-plots (Plots 1,3,5,7 and 9)

P0: No P

P1: 44 kg P as triple superphosphate

P2: 87 kg P as triple superphosphate

P3: 131 kg P as triple superphosphate

Plus basal manuring 144 kg N and 83 kg K to all P sub-plots

P applied 7 times, 1986-1991 (spring 1986, autumn 1986 then each autumn up to 1991)

NB 'year' refers to harvest year, the P is applied the previous autumn.

### "N Test" sub-plots (Plots 2,4,6,8 and 10)

N0: No N

N1: 48 kg N calcium ammonium nitrate

N2: 96 kg N calcium ammonium nitrate

N3: 144 kg N calcium ammonium nitrate

N rates rotate each year N0>N3>N2>N1, eg N0 1986, N3 1987, N2 1988, N1 1989, N0 1990

**Cropping:** Spring barley 1986-1991; winter wheat 1992

## Annual Treatments per hectare, 1856-1901:

Nil : No fertilizer or manure

FYM : 35 of farmyard manure since 1876

Nil (FYM) : FYM 1876-1881, no fertilizer or manure 1882-1901

FYM (P) : FYM plus P until 1882, FYM only 1883-1901

FYM (N\*P) : FYM plus N\* and P until 1881, FYM plus P 1882, FYM only 1883-1901

N : 96 kg N as ammonium salts (ammonium sulphate & ammonium chloride)

N\* : 96 kg N as sodium nitrate

P : 34 kg P (as superphosphate 1876-96, from basic slag 1897-1901)

K : 137 kg K as potassium sulphate (91 kg K 1859-74)

Na : 16 kg Na as sodium sulphate

Mg : 11 kg Mg as magnesium sulphate

# Exhaustion Land Experiment Plan

1993-1999

Phase IV

↗ N

<b>Plot 10</b> 101	<b>Plot 8</b> 081	<b>Plot 6</b> 061	<b>Plot 4</b> 041	<b>Plot 2</b> 021
102	082	062	042	022
(PKNaMg) (1876-1901)	(N*PKNaMg) (1876-1901)	(N*) (1876-1901)	(FYM(N*P)) (1876-1901)	(Nil (FYM)) (1876-1901)
103	083	063	043	023
104	084	064 <b>"K Test"</b>	044	024
<b>Plot 9</b> 091 <b>(P3)</b>	<b>Plot 7</b> 071 <b>(P3)</b>	<b>Plot 5</b> 051 <b>(P3)</b>	<b>Plot 3</b> 031 <b>(P3)</b>	<b>Plot 1</b> 011 <b>(P3)</b>
092 <b>(P2)</b>	072 <b>(P2)</b>	052 <b>(P2)</b>	032 <b>(P2)</b>	012 <b>(P2)</b>
(P) (1876-1901)	(NPKNaMg) (1876-1901)	(N) (1876-1901)	(FYM(P)) (1876-1901)	(Nil) (1876-1901)
093 <b>(P1)</b>	073 <b>(P1)</b>	053 <b>(P1)</b>	033 <b>(P1)</b>	013 <b>(P1)</b>
094 <b>(P0)</b>	074 <b>(P0)</b>	054 <b>(P0)</b> <b>"P Test"</b>	034 <b>(P0)</b>	014 <b>(P0)</b>

(not to scale)

## Annual Treatments per hectare, 1993-1999:

### "K Test" (Plots 2,4,6,8 and 10)

Basal manuring: 192 kg N and P to all "K Test" sub-plots  
kg P: 436 in 1992; 131 in 1993; 65 in 1994-98; 22 in 1999

### "P Test" (Plots 1,3,5,7 and 9)

Basal manuring 192 kg N and 83 kg K to all "P Test" sub-plots  
No P applied 1993-1999.

## Annual Treatments per hectare, 1986-1992:

- (P0): No P
- (P1): 44 kg P as triple superphosphate
- (P2): 87 kg P as triple superphosphate
- (P3): 131 kg P as triple superphosphate

## Cropping: Winter wheat 1993-1999

## Annual Treatments per hectare, 1856-1901:

- Nil : No fertilizer or manure
- FYM : 35 of farmyard manure since 1876
- Nil (FYM) : FYM 1876-1881, no fertilizer or manure 1882-1901
- FYM (P) : FYM plus P until 1882, FYM only 1883-1901
- FYM (N\*P) : FYM plus N\* and P until 1881, FYM plus P 1882, FYM only 1883-1901
  - N : 96 kg N as ammonium salts (ammonium sulphate & ammonium chloride)
  - N\* : 96 kg N as sodium nitrate
  - P : 34 kg P (as superphosphate 1876-96, from basic slag 1897-1901)
  - K : 137 kg K as potassium sulphate (91 kg K 1859-74)
  - Na : 16 kg Na as sodium sulphate
  - Mg : 11 kg Mg as magnesium sulphate

# Exhaustion Land Experiment Plan

2000-2006

Phase IV

↗ N

<b>Plot 10</b> 101	<b>Plot 8</b> 081	<b>Plot 6</b> 061	<b>Plot 4</b> 041	<b>Plot 2</b> 021
102	082	062	042	022
(PKNaMg) (1876-1901)	(N*PKNaMg) (1876-1901)	(N*) (1876-1901)	(FYM(N*P)) (1876-1901)	(Nil (FYM)) (1876-1901)
103	083	063	043	023
104	084	064 <b>"K Test"</b>	044	024
<b>Plot 9</b> 091 <b>P</b> <b>(P3)</b>	<b>Plot 7</b> 071 <b>P</b> <b>(P3)</b>	<b>Plot 5</b> 051 <b>P</b> <b>(P3)</b>	<b>Plot 3</b> 031 <b>P</b> <b>(P3)</b>	<b>Plot 1</b> 011 <b>P</b> <b>(P3)</b>
092 <b>(P2)</b> <b>P</b> (P)	072 <b>(P2)</b> <b>P</b> (NPKNaMg)	052 <b>(P2)</b> <b>P</b> (N)	032 <b>(P2)</b> <b>P</b> (FYM(P))	012 <b>(P2)</b> <b>P</b> (Nil)
(1876-1901)	(1876-1901)	(1876-1901)	(1876-1901)	(1876-1901)
093 <b>P</b> <b>(P1)</b>	073 <b>P</b> <b>(P1)</b>	053 <b>P</b> <b>(P1)</b>	033 <b>P</b> <b>(P1)</b>	013 <b>P</b> <b>(P1)</b>
094 <b>(P0)</b> <b>Nil</b>	074 <b>(P0)</b> <b>Nil</b>	054 <b>(P0)</b> <b>Nil</b> <b>"P Test"</b>	034 <b>(P0)</b> <b>Nil</b>	014 <b>(P0)</b> <b>Nil</b>

(not to scale)

## Annual Treatments per hectare, 2000-2006:

### "K Test" (Plots 2,4,6,8 and 10)

Basal manuring to all plots: 192 kg N & 20 kg P each year, and 20 kg Mg every three years

### "P Test" (Plots 1,3,5,7 and 9) 'Maintenance' P to all plots, except Nil

Nil: No fertilizer or manure

P: 20 kg P as triple superphosphate in autumn (61.5kg in 1999 in error)

Basal manuring to all plots: 192 kg N & 124.5 kg K each year, and 20 kg Mg every three years

No P applied 1993-1999.

Annual Treatments per hectare, 1986-1992:

(P0): No P

(P1): 44 kg P as triple superphosphate

(P2): 87 kg P as triple superphosphate

(P3): 131 kg P as triple superphosphate

**Cropping:** Winter wheat, 2000-2006 except Spring wheat in 2001

## Annual Treatments per hectare, 1856-1901:

Nil : No fertilizer or manure

FYM : 35 of farmyard manure since 1876

Nil (FYM) : FYM 1876-1881, no fertilizer or manure 1882-1901

FYM (P) : FYM plus P until 1882, FYM only 1883-1901

FYM (N\*P) : FYM plus N\* and P until 1881, FYM plus P 1882, FYM only 1883-1901

N : 96 kg N as ammonium salts (ammonium sulphate & ammonium chloride)

N\* : 96 kg N as sodium nitrate

P : 34 kg P (as superphosphate 1876-96, from basic slag 1897-1901)

K : 137 kg K as potassium sulphate (91 kg K 1859-74)

Na : 16 kg Na as sodium sulphate

Mg : 11 kg Mg as magnesium sulphate

## Exhaustion Land P and K inputs 1986 onwards

Main plots Sub-plot	P Test plots					K Test plots					Notes
	04	01, 03, 05, 07, 09			All plots	01	02	03, 04, 06, 08, 10		All plots	
Harvest year		kg P/ha			kg K/ha			kg K/ha		kg P/ha	
					Basal K					Basal P	
1986	0	44	87	131	83	0	0	0	0	0	"P Test" started; basal K added
1987	0	44	87	131	83	0	0	0	0	0	
1988	0	44	87	131	83	0	0	0	0	0	
1989	0	44	87	131	83	0	0	0	0	0	
1990	0	44	87	131	83	0	0	0	0	0	
1991	0	44	87	131	83	0	0	0	0	0	
1992	0	44	87	131	83	0	0	0	0	437	Large P applications to "K Test" start so that P is not limiting
1993	0	0	0	0	83	0	0	0	0	131	Applications of P to "P Test" plots withheld
1994	0	0	0	0	83	0	0	0	0	65.4	
1995	0	0	0	0	83	0	0	0	0	65.4	
1996	0	0	0	0	85	0	0	0	0	65.4	
1997	0	0	0	0	83	0	0	0	0	65.4	
1998	0	0	0	0	83	0	0	0	0	65.4	
1999	0	0	0	0	83	0	0	0	0	22	Basal P on "K Test" plots reduced
2000	0	61.5	61.5	61.5	124.5	0	0	0	0	61.5	P treatments were applied at 61.5 kg P in error in 2000.
2001	0	20	20	20	124.5	0	0	0	0	20	
2002	0	20	20	20	124.5	0	0	0	0	20	
2003	0	20	20	20	124.5	0	0	0	0	20	
2004	0	20	20	20	124.5	0	0	0	0	20	
2005	0	20	20	20	124.5	0	0	0	0	20	
2006	0	20	20	20	124.5	0	0	0	0	20	
2007	0	20	20	20	124.5	0	0	62.3	124.5	20	Fresh K added to some "K Test" plots
2008	0	20	20	20	124.5	0	0	62.3	124.5	20	
2009	0	15	15	15	124.5	0	0	62.3	124.5	15	Maintenance P application reduced
2010	0	15	15	15	124.5	0	0	62.3	124.5	15	
2011	0	15	15	15	124.5	0	0	62.3	124.5	15	
2012	0	15	15	15	124.5	0	0	62.3	124.5	15	
2013	0	15	15	15	124.5	0	0	62.3	124.5	15	
2014	0	15	15	15	124.5	0	0	62.3	124.5	15	
2015	0	15	15	15	124.5	0	0	62.3	124.5	15	
2016	0	0	15	15	124.5	0	0	62.3	124.5	15	Maintenance P application to old P1 treatment stopped.
2017	0	0	15	15	124.5	0	0	62.3	124.5	15	
2018	0	0	15	15	124.5	0	0	62.3	124.5	15	
2019	0	0	15	15	124.5	0	0	62.3	124.5	15	
2020	0	0	15	15	124.5	0	0	62.3	124.5	15	
2021	0	0	15	15	124.5	0	0	62.3	124.5	15	
2022	0	0	15	15	124.5	0	0	62.3	124.5	15	
Total input (until 2008)	0	529.5	830.5	1138.5	2284.5	0	0	124.6	249	1138.5	