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

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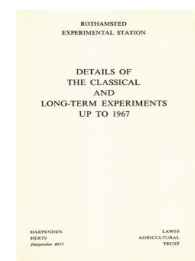
Market Garden Soil - Woburn

Rothamsted Research

MARKET GARDEN EXPERIMENT, WOBURN, LANSOME PIECE, 1942 ONWARDS

The purpose of the experiment was to study the effects of certain bulky organic manures, farmyard manure, sewage sludge, and two types of compost, in building up an agricultural soil for the growth of market garden crops. Certain plots were treated with fertilisers alone to provide controls for the organic treatments.

The crops were grown in a two-year rotation. The experiment falls into two periods: 1942–50 when four crops were grown in the two years; 1951 onwards when three crops were grown in two years. The organic manuring and the basal fertilisers remained practically the same until 1960. The rates of 'Nitro-Chalk' on test were increased in the second period. A new scheme of manuring was introduced in 1961.

First period, 1942-50
(including leeks, 1950–51)

Cropping and design

The two-year rotation occupied two series of plots, one carrying beet followed by cabbage, while the other carried peas followed by leeks. Each series has 40 plots divided into four blocks of 10 plots, certain interactions being partially confounded with block differences.

First year	Red beet (Globe) (sown April, lifted July)
	Winter cabbage (transplanted August, cut December–March)
Second year	Peas (sown March–April, pulled June–July)
	Leeks (transplanted July, lifted January–March).

Size of plots.   0·0125 acre.

Treatments per annum

(i) Organics at 15 and 30 tons   Symbol

	Symbol
Farmyard manure (FYM)	D
Sewage sludge (West Middlesex)	S
Sewage sludge compost* (made with sludge and straw)	T
Vegetable compost (made with farm waste and FYM)	C

(ii) Sulphate of ammonia

    (a) In presence of organics 0 v. 0·6 cwt N

    (b) Without organics 0, 0·6, 1·2, 1·8 cwt N

Basal dressings per annum

0·4 cwt P_2O_5 as superphosphate

0·5 cwt K_2O as muriate of potash

*Composted town refuse in 1942 and 1943.

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Application of manures

(i) Organics ploughed-in in winter and basal dressing broadcast in early spring before red beet and again before peas. No organics or basal dressings were applied to cabbages or leeks.

(ii) The sulphate of ammonia was divided as follows:

	With organics	No organics
Peas and red beet	0, 0·2	0, 0·2, 0·4, 0·6
Cabbages and leeks	0, 0·4	0, 0·4, 0·8, 1·2

The heavier dressings of sulphate of ammonia were applied in divided dressings according to the requirements of the crop.

In the first year, which was preliminary, winter cabbages were grown on both series. They tested FYM, sewage sludge and composted town refuse at 4 and 8 tons (vegetable compost and sewage sludge compost were not available). Sulphate of ammonia at 0·6 cwt N was also tested. In 1943 composted town refuse was again used in place of sludge compost.

Husbandry. Cabbages, leeks and red beet were graded and the numbers and weights in each grade recorded. From 1950 leeks were harvested two rows per plot at a time at intervals during the season. Winter cabbages 1947–48 failed.

Second period, 1951–60

(including leeks 1960-61)

The experiment was recast as follows:

Sequence of crops

First year   Red beet, sown April–May, lifted July–August.
Spring cabbage, planted September–October, cut April–May. (Early potatoes from 1956.)

Second year   Leeks, planted June–July, lifted March–April.

Organic manures. The same four organics were applied to each of the three crops of the rotation at 10 and 20 tons, i.e. 30 and 60 tons every two years as before. Leeks 1960–61 received vegetable compost at half rate.

Basal fertiliser.   0·3 cwt P_2O_5 and 0·3 cwt K_2O as 0:13:13 fertiliser applied to every crop.

Nitrogenous dressings.   These were applied to every crop on the following scale:

In presence of organics, 0, 0·3 cwt N as 'Nitro-Chalk' (N1).

In absence of organics, 0, 0·3, 0·6, 0·9 cwt N as 'Nitro-Chalk' (N1, N2, N3). The heavier dressings were divided; leeks and red beet had N1 and half N2 and half N3 before planting or sowing, the remaining halves later. Spring cabbage had N1, half N2, half N3 as a spring application and the remainder later.

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Husbandry. From 1953 red beet was harvested two rows per plot at a time at intervals during the season. Spring cabbage 1952–53 failed and was replaced by peas; in 1953 also red beet failed and was replaced by white turnips. Spring cabbage 1955–56 failed and early potatoes were grown without further manuring. It was decided to continue this cropping, the organic manures being ploughed down in winter, the fertilisers broadcast on the flat in spring and the potatoes planted by machine.

Third period, 1961–67

Table 58 (pp. 118–119) gives the fertiliser applications, etc., for both Series A and Series B during the period.

1961 (including leeks 1961-62)

Fertiliser plots (additional tests)
 (i) All fertiliser applied before planting or sowing.
 (ii) Half PK (for potatoes) or half NPK (for red beet and leeks) ploughed-in at time of applying organics, remainder before planting or sowing.

  Note: Before planting fertiliser for potatoes applied on the flat.

Organic manure plots
A test was added: no fertiliser v. N1P1K1, applied before planting or sowing.

Both sets of plots were split for a test of sulphate of magnesia applied before planting or sowing. All treatments cumulative.

1962. Applications of sewage sludge (S) and sewage sludge compost (T) were discontinued. FYM replaced vegetable compost (C) except for early potatoes, 1962.

Plots previously treated with sludge and sludge compost were split for a test of P1K1 v. N1P1K1 (rates as 1961), all applied before planting or sowing. Leeks on these plots harvested at one time only, other plots two dates of harvest.

For red beet only, the split was across the direction of the rows, no sulphate of magnesia being applied to this crop.

A comparison of sowing depths ($\frac{3}{4}$, $1\frac{1}{2}$ in.) was made on red beet, each strip of four plots being split for this test. The crop was lifted early, because of excessive bolting, and resown at uniform depth without further manures.

1963. Carrots replaced early potatoes because of an infestation of potato cyst-nematode (*Heterodora rostochiensis*). The carrots were not thinned and were sprayed with a systemic insecticide to control Motley Dwarf virus. The manurial treatments remained the same as for potatoes. No Mg was applied.

1964. Similar to 1963.

1965. A microplot experiment was started on the fertiliser and FYM plots of series B, using red beet. The applications to the fertiliser plots and the nitrogen applications were three-quarters dug in and one-quarter in the seedbed. The S, T and C plots were fallowed. Series A continued with carrots as the crop, and treatments as in 1964.

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TABLE 58

Woburn Market Garden Experiment, treatments and cropping, 1961–67

Note: Where treatments were applied cumulatively the appropriate symbols are entered directly below each other. Otherwise factors are orthogonal unless the contrary is stated. In 1961 only the S and T plots received fertiliser treatments as the D and C plots. For later years see text.

Symbols and treatments

1961-63 $N1 = 0.9$, $N2 = 1.8$ cwt N as 'Nitro-Chalk'; $P1K1 = 1.5$ cwt P_2O_5, 1.5 cwt K_2O (0: 20: 20); $P1K2 = 1.5$ cwt P_2O_5, 3.0 cwt K_2O (0: 14: 28); $Mg = 500$ lb sulphate of magnesia; $PL1 =$ fertilisers applied in the seedbed, $PL2 =$ half PK for potatoes, and half NPK for red beet and leeks ploughed in the remainder as a seedbed application.

1963 $SD =$ BHC/organo mercury seed dressing at 10 oz per cwt seed.

1964 $N1 = 0.45$, $N2 = 0.9$ cwt N as 'Nitro-Chalk'.

1965 $P2K2 = 3.0$ cwt P_2O_5, 3.0 cwt K_2O (0: 20: 20); $Pt = 250$ cwt peat; $N0 =$ none, $N1 = 0.6$, $N2 = 1.2$, $N3 = 1.8$ cwt N as 'Nitro-Chalk'; $S3$ and $S4 =$ singling to 3 in. and 4 in.; $D1$, $D2 =$ FYM at 10 and 20 tons.

1966   *Series A: D and C Plots:* $N0 =$ none, $N1 = 0.9$, $N2 = 1.8$, $N3 = 2.7$ cwt N as 'Nitro-Chalk'. *Fertiliser Plots:* $N1 = 0.9$, $N2 = 1.8$, $N3 = 2.7$, $N4 = 3.6$ cwt N as 'Nitro-Chalk'. *Series B:* $SP0 =$ none, $SP1 = 1.5$, $SP2 = 3.0$ cwt P_2O_5 as superphosphate. $N0 =$ none, $N1 = 0.45$, $N2 = 0.9$ cwt N as 'Nitro-Chalk'.

1967   *Series A:* $N0 =$ none, $N1 = 0.9$ cwt N as 'Nitro-Chalk'. *Series B, Eighth Plots:* $N0 =$ none, $N1 = 0.7$, $N2 = 1.4$, $N3 = 2.1$ cwt N as 'Nitro-Chalk'.

Series A

Fertiliser Plots

Year	Crop	Whole	Half	Quarter
1961	E. Potatoes/Leeks	(N1 v. N2)(P1K1 v. P1K2)(PL1 v. PL2)	(0 v. Mg)	—
1962	Red Beet	(N1 v. N2)(P1K1 v. P1K2)(PL1 v. PL2)	—	—
1963	Carrots/Leeks	(N1 v. N2)(P1K1 v. P1K2)(PL1 v. PL2)	—	—
1964	Red Beet	(N1 v. N2)(P1K1 v. P1K2)(PL1 v. PL2) (1)	—	—
1965	Carrots	(N1 v. N2)(P1K1 v. P1K2)(PL1 v. PL2)	—	(N1 v. N2 v. N3 v. N4) (2)
1966	Red Beet	— (P1K1 v. P2K2) —	(2)	—
1967	Carrots	— (P1K1 v. P2K2) —	(4)	—
		(all at N1)		

D and C Plots

Year	Crop	Whole	Half	Quarter
1961	E. Potatoes/Leeks	(0 v. N1P1K1)	(0 v. Mg)	—
1962	Red Beet	(0 v. N1P1K1)	—	—
1963	Carrots/Leeks	(0 v. N1P1K1)	—	—
1964	Red Beet	(0 v. N1P1K1) (1)	—	—
1965	Carrots	(0 v. N1P1K1)	—	—
1966	Red Beet	(0 v. P1K1)	(3)	(N0 v. N1 v. N2 v. N3) (3)
1967	Carrots	(all at N0)	(4)	—

(1) N rates changed, see under symbols 1964.
(2) $N4 - N3 + N2 - N1$ on half plots.
(3) $N3 - N2 + N1 - N0$ on half plots.
(4) Test of seed (all viable v. ½ viable) on columns of four half plots, also early and late harvesting (randomised on half plots the other way).

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TABLE 58 (continued)

Series B

Fertiliser Plots

		Whole	Half	Quarter	Eighth
1961	Red Beet	(N1 v. N2)(P1K1 v. P1K2)(PL1 v. PL2)	(0 v. Mg)	—	—
1962	E. Potatoes/Leeks	(N1 v. N2)(P1K1 v. P1K2)(PL1 v. PL2)	(0 v. Mg)	—	—
1963	Red Beet (1)	(N1 v. N2)(P1K1 v. P1K2)(PL1 v. PL2)	—	—	—
1964	Carrots/Leeks	(N1 v. N2)(P1K1 v. P1K2)(PL1 v. PL2) (2)	—	—	—
1965	Red Beet	— (P1K1 v. P2K2)	(0 v. Pt) (3) (N''') (3)	(N') (N'')	(S3 v. S4)
1966	Carrots	— (P1K1 v. P2K2)	(0 v. SP1) (P1K1 plots) (0 v. SP2) (P2K2 plots)	(N') (N'')	(N1 v. N2) (4)
1967	Sugar Beet	— (P1K1 v. P2K2)	(0 v. Pt) (N'')	(N') (N'')	—

FYM plots

		Whole	Half	Quarter	Eighth
1961	Red Beet	(0 v. N1P1K1)	(0 v. Mg)	—	—
1962	E. Potatoes/Leeks	(0 v. N1P1K1)	(0 v. Mg)	—	—
1963	Red Beet (1)	(0 v. N1P1K1)	—	—	—
1964	Carrots/Leeks	(0 v. N1P1K1) (2)	—	—	—
1965	Red Beet	(0 v. P1K1)	(0 v. D1) (D1 plots) (N''') (5) (0 v. D2) (D2 plots) (5)	(0 v. D1) (D1 plots) (0 v. D2) (D2 plots) (0 v. D1) (D1 plots) (0 v. D2) (D2 plots) (N') (N'')	(S3 v. S4)
1966	Carrots	(0 v. P1K1)	—	(0 v. SP1)	(N0 v. N1) (4)
1967	Sugar Beet	(0 v. P1K1)	(N''')	(N') (N'')	—

(1) Also (0 v. SD) to columns of 4 half plots.
(2) N rates changed, see under symbols 1964.
(3) Allocated at random (subject to confounding) ignoring (0 v. Mg) 1961 and 1962.
(4) Allocated at random ignoring (S3 v. S4) 1965.
(5) Cumulative FYM (10 tons on D1 plots, 20 tons on D2 plots) v. Residual FYM (no fresh applications) allocated at random (subject to confounding) ignoring (0 v. Mg) 1961 and 1962.

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1966. As 1965 with carrots on Series B microplots, red beet on Series A. The S and T plots of Series A received P2K2.

1967. Series B was taken out of the experiment and put into sugar beet with peat, PK and FYM as in 1965–66, and N tested at four rates. Tops were carted off.

This was the last year of the rotation but residues of the earlier treatments are being measured.

Varieties

Peas: Kelvedon Wonder
Leeks: Musselburgh
Red Beet: Crimson Globe (1943–49)
    Detroit (1950–66)
Cabbage: Christmas (planted 1942, Series A)
    January King (planted 1942, Series B, also 1943, 1945, 1947, 1948, 1950)
    Christmas and Savoy (planted 1946)
    January King and Savoy (planted 1949), two blocks each variety
    Durham Early (planted 1951–56)
Early Potatoes: Arran Pilot
Carrots: Early Market (1963–65)
    Cluseed New Stump-rooted (1966)
Sugar Beet: Klein E.

Liming

From 1943 to 1945 ground chalk at 29 cwt/acre was applied before planting cabbages. In 1948 and 1949 an amount of ground chalk was applied for the red beet equal in weight to all the ammonium sulphate previously applied up to date. In 1950 chalk was applied to red beet equal to the amount of ammonium sulphate used on the previous four crops on this block. In 1951 certain plots which were still acid were corrected individually. From 1952 onwards 10 cwt CaO as 18–20 cwt of ground chalk was given before every crop of red beet. In 1955 this dressing was applied to spring cabbages also. In 1958 the quantity of ground chalk was raised to 23 cwt. In 1963 the dressing to red beet was 20 cwt.

Field name. The site of the experiment is now called Lansome I.

References

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For bolting of red beet see Mann, H. H. (1951). The effect of manures on the bolting of the beet plant. *Ann. appl. Biol.* **38**, 435–443.
For a summary of the results see *Rep. Rothamsted exp. Stn for 1962*, 186–193.
For discontinuation of sewage sludge see Le Riche, H. H. (1968). Metal contamination of soil in Woburn Market Garden Experiment resulting from the application of sewage sludge. *J. agric. Sci,* **71**, 205–208.

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TABLE 59

Market garden experiment, Woburn, Lansome Field

Total produce, tons. Means 1944–50

First crops after organic manures

Treatment	Rate of manuring (tons)	Red beet (1944–45, 1947–50) (6 years) (excluding unmarketable produce)				Green peas (1944–50) (7 years)			
		cwt N 0	0·2	Mean	Diff.	cwt N 0	0·2	Mean	Diff.
No organics		(±0·404)		(±0·286)	(±0·571)	(±0·166)		(±0·118)	(±0·235)
		2·03	2·75	2·39	0·72	1·81	1·84	1·82	0·03
		3·02*	3·16†	3·09	0·14	1·86*	1·82†	1·84	−0·04
FYM (D)	15	4·84	4·90	4·87	0·06	2·38	2·23	2·31	−0·15
	30	6·52	6·64	6·58	0·12	2·27	2·04	2·16	−0·23
Mean		5·68	5·77	5·72	0·09	2·32	2·14	2·24	−0·18
		(±0·286)		(±0·202)	(±0·404)	(±0·118)		(±0·083)	(±0·166)
Sewage sludge (S)	15	4·21	4·64	4·43	0·43	1·84	2·04	1·94	0·20
	30	5·31	4·94	5·13	−0·37	1·68	1·84	1·76	0·16
Mean		4·76	4·79	4·78	0·03	1·76	1·94	1·85	0·18
Compost (C)	15	3·87	4·57	4·22	0·70	2·36	2·22	2·29	−0·14
	30	5·74	5·98	5·86	0·24	2·06	2·20	2·13	0·14
Mean		4·80	5·27	5·04	0·47	2·20	2·21	2·21	0·01
Compost (T)	15	3·76	3·73	3·74	−0·03	2·24	2·10	2·17	−0·14
	30	4·61	5·24	4·92	0·63	2·27	2·12	2·20	−0·15
Mean		4·18	4·48	4·33	0·30	2·26	2·11	2·18	−0·15

* 0·4 cwt N. † 0·6 cwt N.

Second crops after organic manures

Treatment	Rate of manuring (tons)	Winter cabbages (1944–46, 1948–50)* (6 years)				Leeks (1944–50)* (7 years)			
		cwt N 0	0·4	Mean	Diff.	cwt N 0	0·4	Mean	Diff.
No organics		(±0·246)		(±0·174)	(±0·348)	(±0·160)		(±0·113)	(±0·226)
		2·63	4·32	3·48	1·69	2·20	2·67	2·44	0·47
		5·24†	5·67‡	5·46	0·43	2·71†	2·90‡	2·80	0·19
FYM (D)	15	4·17	5·41	4·79	1·24	3·16	3·07	3·11	−0·09
	30	5·12	6·17	5·64	1·05	3·84	3·89	3·86	0·05
Mean		4·64	5·79	5·22	1·15	3·50	3·48	3·49	−0·02
		(±0·174)		(±0·123)	(±0·246)	(±0·113)		(±0·080)	(±0·160)
Sewage sludge (S)	15	5·21	6·56	5·88	1·35	3·11	3·06	3·08	−0·05
	30	6·97	7·11	7·04	0·14	3·47	3·66	3·56	0·19
Mean		6·09	6·84	6·46	0·75	3·29	3·36	3·32	0·07
Compost (C)	15	3·87	5·04	4·46	1·17	2·89	3·25	3·07	0·36
	30	4·85	5·91	5·38	1·06	3·52	3·50	3·51	−0·02
Mean		4·36	5·48	4·92	1·12	3·20	3·37	3·29	0·17
Compost (T)	15	3·87	4·97	4·42	1·10	2·89	3·33	3·11	0·44
	30	4·40	6·17	5·28	1·77	3·15	3·18	3·16	0·03
Mean		4·14	5·57	4·85	1·43	3·02	3·25	3·14	0·23

* Years of sowing and transplanting. † 0·8 cwt N. ‡ 1·2 cwt N.
Number of years given in brackets.

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TABLE 60

Market garden experiment, Woburn, Lansome Field

Total produce: tons.   Means 1951–60

Treatment	Rate of manuring (tons)	Red beet (1951–52, 1954–60) (9 years) cwt N 0	0·3	Mean	Diff.	Leeks (saleable produce) (1951–60)* (10 years) cwt N 0	0·3	Mean	Diff.
No organics		(±0·784) 4·21 8·52†	6·19 7·43‡	(±0·554) 5·20 7·98	(±1·109) 1·98 −1·09	(±0·190) 2·56 4·39†	3·77 4·07‡	(±0·134) 3·16 4·23	(±0·269) 1·21 −0·32
FYM (D)	10 20	9·25 15·74	12·24 16·89	10·74 16·31	2·99 1·15	4·47 5·77	5·16 6·01	4·81 5·89	0·69 0·24
Mean		12·49 (±0·554)	14·56	13·52 (±0·392)	2·07 (±0·784)	5·12 (±0·134)	5·58	5·35 (±0·095)	0·46 (±0·190)
Sewage sludge (S)	10 20	10·99 12·61	11·45 14·18	11·22 13·39	0·46 1·57	5·08 5·10	5·02 5·39	5·05 5·25	−0·06 0·29
Mean		11·81	12·82	12·30	1·02	5·09	5·20	5·15	0·11
Compost (C)	10 20	10·18 12·35	12·38 16·07	11·28 14·21	2·20 3·72	4·71 5·49	5·21 5·81	4·96 5·65	0·50 0·32
Mean		11·27	14·22	12·74	2·95	5·10	5·51	5·31	0·41
Compost (T)	10 20	10·00 13·78	11·95 15·29	10·98 14·53	1·95 1·51	4·87 5·20	5·23 5·60	5·05 5·40	0·36 0·40
Mean		11·89	13·62	12·75	1·73	5·03	5·42	5·22	0·39

Treatment	Rate of manuring (tons)	Spring cabbages (1951, 1953–54)* (3 years) cwt N 0	0·3	Mean	Diff.	Potatoes (tubers) (1956–60) (6 years) cwt N 0	0·3	Mean	Diff.
No organics		(±0·696) 2·20 6·28†	4·68 6·31‡	(±0·492) 3·44 6·30	(±0·984) 2·48 0·03	(±0·260) 4·03 6·43†	5·38 6·35‡	(±0·184) 4·70 6·39	(±0·367) 1·35 −0·08
FYM (D)	10 20	5·48 7·44	6·47 8·65	5·98 8·05	0·99 1·21	6·72 7·79	7·54 8·26	7·13 8·03	0·82 0·47
Mean		6·46 (±0·492)	7·56	7·02 (±0·348)	1·10 (±0·696)	7·25 (±0·184)	7·90	7·58 (±0·130)	0·65 (±0·260)
Sewage sludge (S)	10 20	7·07 9·02	8·19 10·05	7·63 9·54	1·12 1·03	6·44 7·06	6·75 7·37	6·59 7·21	0·31 0·31
Mean		8·04	9·12	8·58	1·08	6·75	7·06	6·90	0·31
Compost (C)	10 20	5·19 6·32	6·92 7·90	6·05 7·11	1·73 1·58	6·43 7·39	7·45 7·80	6·94 7·59	1·02 0·41
Mean		5·75	7·41	6·58	1·66	6·91	7·62	7·27	0·71
Compost (T)	10 20	5·73 7·16	7·21 8·37	6·47 7·77	1·48 1·21	6·59 7·55	6·95 7·86	6·77 7·70	0·36 0·31
Mean		6·44	7·79	7·12	1·35	7·07	7·40	7·24	0·33

* Years of sowing and transplanting.   † 0·6 cwt N.   ‡ 0·9 cwt N.
Number of years given in brackets.

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