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Scheme for Rotation Experiments

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SCHEME FOR CONTINUOUS ROTATION EXPERIMENTS COMMENCING 1930

Rotation I.—FOUR COURSE ROTATION EXPERIMENT.

The Rotation experiment in Great Hoos field was designed primarily for investigating the residual effects of certain humic and phosphatic fertilisers. Previous rotation experiments, at Rothamsted and elsewhere, suffered from a radical defect in design, which resulted in large experimental errors. The arrangement of these experiments was such that with the same crop, the same treatment fell repeatedly on the same plot of land, and repetitions thus did nothing to eliminate permanent soil differences between the plots. The present experiment avoids this defect by ensuring that the period of the cycle of crop rotation differs from the period of the cycle of manurial treatment.

The cropping follows a Norfolk Rotation, involving a four year cycle of barley, seeds, wheat, swedes. The seeds mixture is Commercial White Clover and Italian Rye-grass, selected in order to lessen the risk of Clover sickness. To minimise the risk of Frit-fly attack in the subsequent wheat crop, the seeds ley is ploughed in before the middle of August.

There are four areas (termed "Series"), each bearing one crop of the rotation, so that all four crops are represented annually.

Treatments.

The Treatments compared are :

Humic fertilisers	{	1. Dung.
		2. Adco. compost.
		3. Straw and Artificials.
Phosphatic fertilisers	{	4. Superphosphate.
		5. Rock phosphate (Gafsa).

Any given plot receives always the same treatment, but the treatment is applied to the plot only once in five years. The period of the manurial cycle (five years) thus differs from that of the crop rotation (four years).

Information is thus obtained of the effect of the fertilisers, not only in the year of application, but also in the first, second, third and fourth years after application.

Each "series" of the experiment comprises twenty-five plots, and in the fifth year of the experiment and in succeeding years, all plots will have been treated, and there will be represented for each treatment plots which have had application of fertilisers in the current year, and one, two, three, and four years previously. The harvest results for 1930-33, therefore, belong to the preparatory period, and will not be included in the final analysis.

There is no replication in any one year, but this will be provided by carrying on the experiment over a fixed period. In twenty years, on any given plot each stage of the treatment will have occurred once with every crop.

The quantities of fertilisers to be applied are calculated as follows :

Dung and Adco are each given in quantities which supply 50 cwt. of organic matter per acre. As much straw is applied as went to make the calculated amount of Adco, *i.e.*, that amount which gives 50 cwt. of organic matter per acre in the form of Adco. The quantity of straw applied will in general give a considerably greater amount of organic matter than the Dung or Adco, since there is a loss of organic matter during the maturation of these fertilisers.

The Adco is made in a pit or bin, so that there is no outside unrotted portion. To prevent straw (applied as chaff) blowing away, it is thoroughly soaked before application, and moistened subsequently if necessary.

The nutrient-content of the three humic fertilisers is equalised by adding sulphate of ammonia, muriate of potash and superphosphate, to raise the applications to 1.8 cwt. N per acre, 3.0 cwt. K_2O per acre, and 1.2 cwt. P_2O_5 per acre. The artificials given with the straw are applied in three doses, to minimise loss by leaching.

The phosphatic fertilisers of treatments 4 and 5 are given at the rate of 1.2 cwt. total P_2O_5 per acre, and with them are given sulphate of ammonia at the rate of 1.8 cwt. N per acre, and muriate of potash at the rate of 3.0 cwt. K_2O per acre.

The rock phosphate is Gafsa, ground so that 90 per cent passes through the 120 mesh.

The artificials given with the humic fertilisers are all applied with them in the first year of the manurial cycle.

The phosphatic fertilisers of treatments 4 and 5 are applied only in the first year of the manurial cycle, but the accompanying sulphate of ammonia and muriate of potash are applied one fifth annually throughout the cycle.

Time of Application of Fertilisers.

In determining the time of application of the fertilisers, the principle followed has been to give the fertilisers to each crop at a time when they are likely to be most effective.

The scheme adopted is as follows :

(1) *Wheat*.—Dung and Adco and accompanying artificials in one dose in the Autumn. Straw in one dose in Autumn, but accompanying artificials split into three doses, one applied in Autumn, the remainder through the Winter.

Treatments 4 and 5. Phosphates and potash in seed-bed.

Sulphate of Ammonia of treatments 4 and 5, split into two parts, one applied in the seed-bed, the other as a spring top dressing.

(2) *Clover*.—Dung and Adco and accompanying artificials in one dose in Autumn, unless plant is very weak, when the manures should be split into two or three doses.

Straw and artificials—application to be determined by state of plant, but to be completed by the end of January.

Treatments 4 and 5. Phosphates and potash in the Autumn.

Sulphate of Ammonia in two doses, one in Autumn, and one in Spring.

(3) *Barley and Swedes*.—Dung and Adco and accompanying artificials in one dose in Autumn.

Straw in one dose in Autumn, and accompanying artificials in three doses, one in Autumn, and the remaining two through the winter.

Treatments 4 and 5. All artificials to be given in the seed-bed.

Arrangement of Plots.

The experiment consists of four series of plots, each series growing one crop of the Norfolk rotation. Each series has 25 plots, in 5 blocks of 5 plots each. Each treatment is assigned to one plot in each block, chosen at random ; and each block has one treated plot in each year, chosen initially at random ; finally each treatment is applied once in each year to one plot in each series.

Hence treatments are assigned as to five Randomised blocks of five plots each in each series, but a Latin Square scheme determines the year of application of the treatment in each series.

The plots are approximately 1/40th acre in area (.02436 acre in series A, B and C, but .023347 acre in series D).

First Series (Plots 1-25).—Years of Application.

TREATMENTS :	Blocks.					
	A	B	C	D	E	(I, II, III, IV, V
1	III	V	I	II	IV	=the successive
2	I	III	IV	V	II	years of the
3	V	I	II	IV	III	cycle.)
4	II	IV	III	I	V	
5	IV	II	V	III	I	

(Hence treatment 1 is applied to the appropriate plot in block C in the first year of the experiment ; to that in block D in the second year ; A in the third, and so forth.)

First Series A H (Plots 1-25) Seeds Hay.—Layout in 1929-30.

BLOCKS	1		2		3		4		5	
	Upper Figure—Plot Number	Lower Figure—Treatment Number	Upper Figure—Plot Number	Lower Figure—Treatment Number	Upper Figure—Plot Number	Lower Figure—Treatment Number	Upper Figure—Plot Number	Lower Figure—Treatment Number	Upper Figure—Plot Number	Lower Figure—Treatment Number
a	1	5	2	2	3	1	4	3	5	4
b	6	5	7	1	8	3	9	4	10	2
c	11	3	12	2	13	5	14	4	15	1
d	16	1	17	3	18	4	19	5	20	2
e	21	4	22	1	23	5	24	3	25	2

Hence plot 15 receives treatment 1 in the first year of the experiment, etc.

Second Series (Plots 26-50).—Years of Application.

TREATMENTS :	Blocks.				
	A	B	C	D	E
1	IV	II	III	I	V
2	I	III	II	V	IV
3	II	V	IV	III	I
4	III	I	V	IV	II
5	V	IV	I	II	III

Second Series A W (Plots 26-50) Wheat.—Layout in 1929-30.

BLOCKS	a	26 3	27 2	28 5	29 4	30 1
	b	31 4	32 2	33 1	34 5	35 3
	c	36 1	37 4	38 3	39 5	40 2
	d	41 4	42 5	43 3	44 2	45 1
	e	46 2	47 4	48 3	49 1	50 5

Third Series (Plots 51-75).—Years of Application.

TREATMENTS :			Blocks.		
1	A	B	C	D	E
2	V	III	IV	I	II
3	III	IV	I	II	V
4	I	V	II	IV	III
5	IV	II	V	III	I
	II	I	III	V	IV

Third Series A B (Plots 51-75) Barley.—Layout in 1929-30.

BLOCKS	a	51 3	52 4	53 1	54 2	55 5
	b	56 3	57 4	58 5	59 2	60 1
	c	61 2	62 4	63 3	64 1	65 5
	d	66 5	67 1	68 3	69 4	70 2
	e	71 4	72 2	73 1	74 5	75 3

Fourth Series (Plots 76-100).—Years of Application.

TREATMENTS :			Blocks.		
1	A	B	C	D	E
2	IV	II	I	V	III
3	I	IV	III	II	V
4	V	I	II	III	IV
5	II	III	V	IV	I
	III	V	IV	I	II

Fourth Series A T (Plots 76-100) Turnips.—Layout in 1929-30.

BLOCKS	a	76 4	77 2	78 5	79 3	80 1
	b	81 5	82 2	83 1	84 4	85 3
	c	86 2	87 1	88 5	89 4	90 3
	d	91 2	92 4	93 1	94 5	95 3
	e	96 5	97 2	98 3	99 1	100 4

Rotation II.—SIX COURSE EXPERIMENT.

This experiment is designed to furnish data on the effect of varying amounts of the three standard fertilisers, nitrogen, phosphate, and potash, on the yield of six crops of a rotation in the different weather conditions of successive years.

Rotation.

The six courses of the rotation are : barley, clover hay, wheat, potatoes, forage-crop, sugar-beet. The forage-crop consists of equal parts (1 bushel per acre each) of rye, beans and vetches. It is sown in autumn, cut green and followed by a catch crop of mustard. The mustard is ploughed in in early autumn, and followed by rye to be ploughed in before sowing sugar-beet.

The variety of barley used is Plumage-Archer, and of wheat Yeoman II.

Arrangement.

There are six areas, called "series," in Long Hoos IV, which are cropped in this rotation so that each crop is represented every year. There are fifteen plots of 1/40th acre in each series, each of which receives a different treatment. Thus there is no replication of a given crop with a given treatment in any one year. Plots do not receive the same treatments throughout, but on each plot the fifteen treatments follow one another in a definite order in successive years, and in this way cumulative effects of a treatment are avoided.

Treatments.

The fifteen treatments are :

- Nitrogen set. 4, 3, 2, 1, 0 units of N, each with 2 units P and 2 units K.
- Phosphate set. 4, 3, 2, 1, 0 units of P, each with 2 units K and 2 units N.
- Potash set. 4, 3, 2, 1, 0 units of K, each with 2 units N and 2 units P.
- 1 unit of N=0.15 cwt. of N per acre
- 1 unit of P=0.15 cwt. of P₂O₅ per acre.
- 1 unit of K=0.25 cwt. of K₂O per acre.

The fertilisers used are Sulphate of Ammonia, Superphosphate and Muriate of Potash. The amount of Superphosphate applied is calculated on the basis of total P₂O₅ content.

The potassic and phosphatic fertilisers are applied to the autumn sown crops, wheat and forage-mixture, and to the clover, sown under barley in the previous spring, in the Autumn, and the nitrogenous fertiliser is given as a spring top dressing. The spring sown crops receive all their fertilisers at the time of sowing.

Within each of the three sets of treatments, the treatments 4, 3, 2, 1, 0 units follow each other in that order in successive years.

On series A, C, E the order of the sets of treatments is N, P, K, and on series B, D, F, the order is N, K, P, *i.e.*, on plots of series A, C, E treatment ON is followed by treatment 4P, OP by 4K, and OK by 4N, while on series B, D, F, ON is followed by 4K, OK by 4P, and OP by 4N.

Continuance of the Experiment.

After 30 years on the same land, each plot has completed 5 rotations by crops, and 2 by treatments. If continued for a further period, it will be necessary to omit one stage of the crop rotation on each series, without breaking the sequence of manurings. After two such breaks the experiment could be continued until every crop with every treatment had occurred on each plot.

Estimate of Error.

Although there is no actual replication, an estimate of error can be made from the deviations of the Yield/Quantity of fertiliser curve, from a smooth form.

In 1929-30 the six crops of the rotation were scattered in various fields of the farm, so that the experiment proper started on its permanent site in Long Hoos IV in season 1930-31. The lay-out of the plots in the latter season is shown in the plan.

Rotation II, Six Course—Long Hoos (Section 4) 1930-31.

First Series—B W (Plots 1-15) Wheat.

1 3P	2 OP	3 ON	4 4K	5 2K
6 4N	7 2P	8 3N	9 OK	10 1K
11 1P	12 2N	13 1N	14 3K	15 4P

Second Series.—B S (Plots 16-30) Sugar Beet.

16 3N	17 4P	18 2P	19 3P	20 3K
21 ON	22 2N	23 1P	24 OK	25 4N
26 IN	27 OP	28 4K	29 2K	30 1K

Third Series.—B B (Plots 31-45) Barley.

31 2K	32 OK	33 OP	34 2P	35 3N
36 3K	37 1K	38 4N	39 4K	40 ON
41 4P	42 3P	43 1P	44 2N	45 IN

Fourth Series.—B C (Plots 46-60) Clover.

46 3P	47 OP	48 1K	49 4N	50 2N
51 1P	52 4K	53 2K	54 3N	55 IN
56 2P	57 OK	58 3K	59 ON	60 4P

Fifth Series.—B P (Plots 61-75) Potatoes.

61 4P	62 OK	63 1P	64 OP	65 IN
66 3K	67 1K	68 2P	69 ON	70 4K
71 2K	72 3P	73 4N	74 2N	75 3N

Sixth Series.—B F (Plots 76-90) Forage-Crop (followed by Mustard and Rye).

76 4K	77 OP	78 3K	79 OK	80 ON
81 2P	82 3P	83 4N	84 2N	85 3N
86 1P	87 2K	88 1K	89 4P	90 IN

Upper Figure—Plot Number.
Lower Figure—Treatment Symbol.