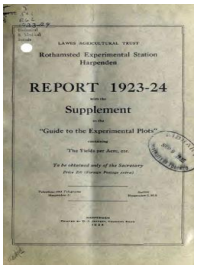
Report for 1923-1924 With the Supplement to the Guide to the Experimental Plots Containing the Yields per Acre Etc.



Full Table of Content

Fertiliser Investigations:

Rothamsted Research

Rothamsted Research (1925) *Fertiliser Investigations: ;* Report For 1923-1924 With The Supplement To The Guide To The Experimental Plots Containing The Yields Per Acre Etc., pp 16 - 24 **- DOI: https://doi.org/10.23637/ERADOC-1-116**

of ammonia in the experiments at Rothamsted and at outside centres inspected by us were as follows :—

	1922 Rothamsted.	1923 Rothamsted.	1924 Rothamsted.	1924 Outside Centres.	Average of all Soils and Seasons to 1920
Wheat, bu. ...	3·25			4·3–6	4·5
Barley, bu. ...	5·5	4·5	8·16	3·5	6·5
Oats, bu. ...		8.3			7
Potatoes, cwt.	20	22–25	20		20
Swedes, cwt.	20	25	5–9	30	20 N. Country 10 S. Country

SIZE OF DRESSING AND TIME OF APPLICATION.

The effect of doubling the nitrogenous dressing and supplying 2 cwt. sulphate of ammonia per acre is to give a further increase in crop. In the case of cereals this second increase is not infrequently greater than the first, so that the effect of the double dressing is to give more than double the increase obtained from the single one. This was shown both in 1923 and 1924; the yields per acre were :—

	No Nitrogen.	1 cwt. Sulphate of Ammonia.	2 cwt. Sulhpate of Ammonia.	Increment in Yield for 1st cwt.	Increment in Yield for 2nd cwt.
1923 Oats, bu ...	29·2	37·3	46·5	8·1	9·2
Straw, cwt.	19	26	36	7	10
1924 Barley, bu.	23·9	32·5	42·7	8·6	10·2

In the case of potatoes, however, the second increment in yield is usually less than the first, though the total effect of the higher dressing still remains profitable because of the higher value of the potato crop.

The results have been, in tons per acre :—

	No Nitrogen.	1½ cwt. Sulphate of Ammonia.	3 cwt. Sulphate of Ammonia.	4½ cwt. Sulphate of Ammonia.	Increment in Yield for 1st dose.	Increment in Yield for 2nd dose.	Increment in Yield for 3rd dose.
1923 ...	12·0	13·7	15·1	14·8	1·7	1·4	Nil
1924 ...	8·0	9·5	9·4	—	1·5	Nil	—

The effect of the nitrogenous dressing depends on its time of application. For cereals it has happened that the later dressings, especially when large, have been more effective than the earlier ones (p. 118). For potatoes it has hitherto always happened at Rothamsted that the application of the sulphate of ammonia with the seed has been more effective than the later top dressing when the plants are showing through the ground. Swedes appear to behave in the opposite way. The physiological basis of this problem of nitrogen intake and nitrogenous efficiency is being studied by Dr. Gregory.

https://doi.org/10.23637/ERADOC-1-116

CHLORIDES AND SULPHATES AS FERTILISERS.

Farmers now have the choice of muriate or sulphate of potash : and they can also have the choice of muriate or sulphate of ammonia. The experiments with potassic fertilisers are described under " Potatoes." Our experience with the muriate of ammonia is that it is less effective than the sulphate for potatoes but more effective for barley. The difference depends on the rainfall during the months of March, April and May and becomes less as the rainfall increases. The average of all the results at Rothamsted has been as follows :—

	1921	1922	1923	1924
Effectiveness of muriate when that of Sulphate = 100 ... ... Corn ...	106	103	109	104
Potatoes	(112)*	95	92	100
Rainfall—March, April and May (inches)	4·08	7·38	5·64	8·95

*Crop almost failed ; 2 tons per acre only.

The chloride of ammonia has had a remarkable effect on the grain of barley as is described below.

BARLEY.

During the past three years an extended investigation into the effect of manures on the yield and quality of barley has been carried out at Rothamsted and on certain good barley farms in various parts of the country, the work being done in connection with the Research Scheme of the Institute of Brewing. The variety grown is Plumage Archer, and seed from one and the same field was used at all the centres.

The results show a considerable degree of concordance among themselves, but they differ in several important respects from the current teachings of agricultural science. It is usually recommended that the manuring for barley should be mainly phosphatic, nitrogen being given only after a corn crop and potash but rarely. Out of 30 different tests this recommendation would have involved loss of money in no less than 26. The actual yields are given on p. 114; the average reduction in yield in bushels per acre, consequent on the omission of each fertiliser during the three years 1922, 1923 and 1924, has been :—

Decrease due to omission of :—	After a straw crop.	After roots fed off.	After potatoes or beets (well manured).	Mean of all experiments.
1 cwt. sulphate of ammonia ...	5·8	3·9	6·7	5·4
3 cwt. super-phosphate	0·9	[0·5]	1·2	0·5
1½ cwt. sulphate of potash	[1·1]	1·3	1·1	0·3

(The figures in brackets are increases and not decreases.)

https://doi.org/10.23637/ERADOC-1-116

The reasons for this unexpected result are probably two :—

1. The modern varieties of high quality barley, such as Plumage Archer, are stiffer in the straw than the older ones, and therefore can carry larger crops of grain without risk of being lodged. Apparently, therefore, they can safely receive more nitrogenous manuring.

2. Good farmers now realise the importance of giving ample dressings of superphosphate to their root crops and sufficient of this fertiliser generally remains in the soil to satisfy the needs of the barley. Potash and phosphates intended for the seeds mixture can, of course, be applied to the barley in which they are sown. The barley may derive benefit, but the profit from these manures must come from the seeds.

One of the distinguishing features of the scheme is that all the experimental barleys are examined by expert maltsters appointed by the Institute of Brewing Research Committee, and are afterwards malted separately and the malts fully analysed.

It is shown that the use of a nitrogenous manure even after roots folded off has not adversely affected the valuation of the barley or the value of the malt, but that the omission of potash from the manure lowered some of the desirable qualities of the malt in 1922, though not apparently in 1923. At each centre the heaviest crops obtainable by manuring have been valued as high, or nearly as high, per quarter, as any other samples of the same set, and it is clear that manurial schemes can be devised which will enhance the present yield without detriment to valuation. So far as the investigation has gone it suggests that farmers using a good modern variety of barley can aim at the biggest crop that will stand, and they can use the appropriate fertiliser to secure this without fear of loss of valuation.

Thus, for the season 1923, the figures for valuation were :—

Valuation per quarter of 448lb., 1923 barleys : made January, 1924.

	Rotham-sted.	East Lothian.	Eyton.	Chisel-borough.	Walcott.	War-minster.	Lincs. Wolds.
1 cwt. sulphate of ammonia	57/–	49/6	49/–	47/–	41/6	52/–	42/–
No Nitrogen	56/–	49/–	50/–	46/–	41/–	52/–	41/6

A remarkable effect is produced when the chloride (or muriate) of ammonia is substituted for the sulphate. In every instance the valuation of the grain has been raised and its nitrogen content lowered. This is shown by the following table :—

Season.	Valuation of Barley. per qr. of 448 lb.		N. content of grain per cent. of dry matter.	
	Sulphate of Ammonia.	Ammonium Chloride.	Sulphate of Ammonia.	Ammonium Chloride.
1922 ...	31/–	36/–	1·647	1·602
1923 ...	57/–	58/–	1·544	1·485
1924 ...	63/6	64/–	1·517	1·495

https://doi.org/10.23637/ERADOC-1-116

The result is all the more interesting in that this is the only manurial method hitherto tested which has consistently improved the quality of the grain. Other treatments have acted sometimes one way and sometimes the other, the change being usually small and unpredictable.

When yield is combined with the valuation and allowance is made for tail corn there is found to be a considerable difference in money value per acre in favour of the chloride :—

Yield (measured bushels per acre) and Money Value of Barley per Acre.

	Sulphate of Ammonium.		Ammonium Chloride.		Difference in favour of Chloride as against Sulphate.
	Yield.	Money Value per Acre.	Yield.	Money Value per Acre.	
1922 ...	36.0	136/–	35.7	156/–	20/–
1923 ...	32.5	239/–	35.6	265/–	26/–
1924 ...	29.8	238/–	29.7	249/–	11/–

In the course of the work it has become clear that the method of valuation commonly adopted does not always work out quite fairly either to the buyer or the farmer. On the loams the estimate has usually been tolerably correct; the value of the malt obtained has paid the cost of the barley, the transport, expenses and profits of malting and other charges. But on the lighter soils, the barley has not generally been as good as it looked, so that the value of the resulting malt did not pay all the charges. On the chalk and limestone soils the barley turned out better than it looked; the farmer received less than he deserved and the malt gave an additional profit to the maltster.

These results are quite intelligible. The buyer judges from certain external appearances of the barley which are on the whole correlated with the value of the resulting malt. But the correlations between the external characteristics and chemical composition are liable to be affected by changes in environment, and it need occasion no surprise that a correlation holding good on loams may be modified in one direction on a sandy soil, and in another on a chalk soil.

The malting and brewing part of the investigation lies outside the scope of Rothamsted, and is carried out entirely by the Institute of Brewing, but the Station, at the cordial invitation of the Institute, is keeping in close touch with the work.

BASIC SLAG AND GRASS LAND.

It is well known that basic slag produces excellent results on many grass fields, especially on the Boulder clays where there is much bent grass and only little wild white clover, but on a number of fields it fails to act.

Two causes of failure are already known, and methods of dealing with them have been worked out :—

(1) The land may be too sour, requiring a dressing of lime before the slag can act.

https://doi.org/10.23637/ERADOC-1-116

(2) There may be insufficient potash; this may be supplied by addition of kainit, 20 per cent. potash salts, etc.

All basic slags, however, do not behave alike. Examination shows that they fall into two great groups: those in the making of which fluorspar was used: and those to which no fluorspar was added. Field experience shows that the fluorspar slags are often less effective than the others: chemical examination indicates that they contain some of their phosphate in the form of fluorapatite, a substance having little, if any, value to plants. The slags free from fluorspar, on the other hand, contain some, if not all, of their phosphate in the form of silico-phosphate, which is of very considerable value to plants. Mr. Page has developed a method for ascertaining the amount of fluorine in slags, from which can be calculated the maximum value for the quantity of fluorapatite present. Some of the results are:—

Slag No.	(1) Total Phosphate, per cent. of slag.	(2) Citric Solubility, per cent. of total phosphate.	(3) Fluorapatite (little value) per cent. of slag.	(4) Silico and other phosphates (much value) per cent. of slag.
1	42·5	77·2	1·4	41·1
2	29·2	91·0	Nil	29·2
3	28·9	16·4	26·9	2·0
4	25·1	98·4	Nil	25·1
5	24·3	30·0	22·0	2·3
6	21·1	27·7	12·3	8·8
7	19·8	70·9	Nil	19·8
8	18·0	81·3	1·3	16·7
9	17·8	37·7	17·1	0·7
10	17·2	78·7	1·4	15·7

(1) Total phosphoric oxide (P_2O_5) multiplied by 2.18 to convert into the equivalent quantity of tricalcic phosphate ($Ca_3(PO_4)_2$).

(2) Percentage of the total phosphoric oxide (P_2O_5) which is soluble in the official 2% citric acid solution.

(3) Calculated from fluorine present, assuming all to be in form of fluorapatite.

(4) The remaining phosphate.

The slags are arranged in order of total phosphate and therefore approximately in order of price. Reference to the last column shows, however, that they differ considerably in their content of effective phosphates. Thus slags 2 and 3 are rated equal by the ordinary analysis and might be offered at the same price by a merchant acting in perfectly good faith and honesty. In the field tests No. 3 is less effective than No. 2. Mr. Page's method shows that it may contain most of its phosphorus in the non-effective form of fluorapatite, while No. 2 contains all its phosphates in the effective forms. The citric solubility test discriminates between these slags but its indications are not always very clear. The fluorine method promises to be more helpful.

https://doi.org/10.23637/ERADOC-1-116

The new method does not, however, enable the slag to be completely characterised and there are still differences in effectiveness which cannot be explained. Slags No. 1, 6, 7 and 8 were compared in the sheep grazing trials at Rothamsted over a period of four years. The gains in live weight of sheep over those obtained on the unmanured plots have been :—

	1921	1922	1923	1924	Total benefit in 4 years., lb. live weight per acre. Slagged over unslagged land.
Slag No. 7	50	19	62	18	149
,, ,, 8	Nil	Nil	Nil	30	30
,, ,, 6	Nil	Nil	15	Nil	15
,, ,, 1	Nil	21	7	Nil	28

It is obvious that No. 7 is by far the most effective of these slags, being better even than No. 1 which was known to act well on other soils, but no chemical test so far tried would show this superiority to a prospective purchaser. At the time we obtained the slag neither the makers nor ourselves knew or even suspected that it would prove any better than No. 8 or as good as No. 1, nor can we yet explain why it should be so. It seems clear that somewhere in its history this slag received some treatment which, if it could be repeated on other slags, might greatly enhance their agricultural value. A possible clue has been furnished by the manufacturers and an observation has been made in the chemical laboratory which may furnish the solution of a very attractive problem.

A third important chemical factor has been discovered during the past season by Dr. Brenchley and Mr. Page. Some of the slags examined were found to contain substances harmful to the plant. This does not, of course, mean that they actually damaged the crop : what happened was that in these particular slags the beneficial effect of the phosphate present was in part counteracted by the harmful substance. All these problems are being followed up and the co-operation of the slag makers is secured through the Permanent Basic Slag Committee of the Ministry of Agriculture. In the meantime farmers who have applied slag to their grass and obtained disappointing results are requested to communicate the facts to the Director.

POTATOES.

The experiments with the different potash manures begun in 1921 have been continued (p. 120). The muriate and the sulphate of potash behave nearly but not quite alike, the muriate giving sometimes a slightly better and sometimes a slightly less yield than the sulphate. The determining factor is partly rainfall, the sulphate tending to give the higher yield in drier conditions and the muriate in wetter, but there is something beside this, for in 1924 the sulphate came out the better in spite of the wetness of the season.

Addition of other chlorides (*e.g.*, salt) to the muriate, is, however, injurious; neither kainit nor sylvinite gave the full benefit expected from the potash because of the harmful effect of

https://doi.org/10.23637/ERADOC-1-116

the salt. This is to some extent mitigated by additions of dung, but the crop always falls below that obtainable from the muriate or the sulphate. The results at Rothamsted are :—

YIELD OF POTATOES WHEN SULPHATE OF POTASH IS USED = 100.

	1922		1923		1924	
	Without dung.	With dung.	Without dung.	With dung.	Without dung.	With dung.
Muriate of Potash	106	98	98	105	98	99
Sylvinite	89	—	87	84	108	105
Rainfall (March-May inclusive).	4.08		5.64		8.95	

These fertilisers affect the quality of the potatoes. Of the complete manured plots, those receiving sulphate of potash produce tubers with the highest percentage of dry matter.

Potassic Fertiliser Used.	Percentage Dry Matter of Potato Tubers.				
	Rothamsted. 1922	Rothamsted. 1923	Reaseheath. 1922	Seale-Hayne. 1922	Usk. 1923
Sulphate ...	24·26	21·73	21·68	24·4	23·6
Chloride ...	22·02	20·85	19·63	22·3	22·5
Low Grade Salts	19·68	17·87	17·28	22·7	21·0
No Potash ...	23·07	20·65	17·62	25·7	22·1

The tubers grown with low grade potash salts (kainit, sylvinite) are the lowest in dry matter content, coming out even below those grown without potash.

The percentage of starch in the dry matter is an important quality factor, and in all tubers so far analysed the value comes out higher for the sulphate of potash than for any of the other salts.

Potassic Fertiliser Used.	Yield in tons per acre.	Dry Matter per cent. in Tubers.	Starch per cent. in Dry Matter.	Starch. Tons per acre.
Sulphate	8.30	24·26	65·84	1·325
Chloride	8·32	22·02	64·00	1·175
Low Grade Salts ...	8·06	19·68	58·20	0·925
No Potash	2·47	23·07	57·16	0·325
Control	2·98	23·36	58·20	0·405

Magnesium sulphate continues to give interesting results; its effect on potatoes has been beneficial at several centres though we cannot yet explain why.

Complete Artificials.	Rothamsted. 1922 No Dung.	Rothamsted. 1923 No Dung.	Rothamsted. 1923 Dung.	Blaydon. 1922 No Dung.	Blaydon. 1922 Dung.	Walbottle. 1922 No Dung.	Walbottle. 1922 Dung.	Newton Abbot. 1922 Dung.
No Magnesium Sulphate ...	100	100	100	100	100	100	100	100
With Magnesium Sulphate ...	102	104	104	108	114	118	129	117
	97	108	104					120

https://doi.org/10.23637/ERADOC-1-116

GREEN MANURING.

The importance of increasing the amount of organic matter in the soil is widely recognised, and experiments have been carried out at Rothamsted for some years to determine the best ways in which this could be done. Mr. Page has been studying green manuring, and he has now been able, thanks to the intervention of the Research Council of the Royal Agricultural Society, to arrange for a number of experiments at outside centres, and thus to obtain direct information on the extent to which soil and climatic factors influence the method.

In practice two kinds of green manuring are possible, though they are not always practicable :—

1. Summer catch crops may be turned in before the winter corn.
2. Winter catch crops may be turned in before roots.

In general, the first method can be practiced only on fallow land, early ploughed seeds leys, or land that has carried a crop harvested early, such as a silage or soiling crop. The eastern counties appear to offer the best opportunities for success.

Trials of this method, using mustard as the green crop, are in progress at six centres, one in the west (Gloucestershire), and five in the east (Kent (2), Suffolk, Beds. and Northants.). The results of the test at Rothamsted give a forcible illustration of its value. Mustard was sown on the bare fallow after cleaning on 20th August, 1923. It was turned under on October 18th, and winter oats were drilled at once. The yields of oats in August, 1924, were as follows :—

Basal Manure.	Yield of Oats, bu/acre.		Increase due to Mustard.	
	After Mustard Ploughed in.	After Fallow (no mustard)	Bu.	Per cent.
None	43·3	25·0	18·3	73
5 tons town refuse	51·8	27·1	24·7	91
10 ,, ,, ,,	49·3	30·6	18·7	61
Average	48·1	27·6	20·5	74

The turning in of mustard thus added, on the average, 20 bushels per acre to the crop. The cost per acre for mustard seed and the extra operations involved in drilling and turning under amounts to 18/-, whilst the increased yield of oats was worth 79/6 per acre, without reckoning the value of the extra 9 cwts. of straw per acre.

The turning in of winter catch crops before roots is probably of even greater practical importance. Climatic factors play a great part since the green crops have to pass through the winter : if this is too cold, crops sown in the autumn do not usually make sufficient growth, by the time when the land needs to be prepared for roots, to produce any marked effect on the root yield. It is probably only within the region, with an average winter temperature exceeding 40° F. and an annual rainfall between 30 and 40 inches, that the present set of autumn sown green crops can as a rule be successfully grown for turning under

https://doi.org/10.23637/ERADOC-1-116

in the spring before the roots. The fact that the corn harvest is earlier in this part of the country, so that green crops can be sown earlier, also helps. Outside of this region autumn sown green crops do not in general make enough growth by the spring to be useful for green manuring purposes; this has happened at Rothamsted for three successive seasons (1921-1924).

The problem therefore arises of finding a system of green manuring for roots which is applicable to the colder northern and eastern districts.

Undersowing of green crops in the corn, and possible new crops are being tried : and at certain centres the relative economic values of folding the green crops to sheep, and of turning them in for manure, are being ascertained.

THE LEGUMINOUS CROPS.

Considerable attention has been devoted to the leguminous crops, owing to their great importance in the rotation and as stock foods. The effect of manures applied to the barley on the clover sown in is shown on pp. 114, 115. Sulphate of ammonia had no bad effect on the clover although it increased the yield of barley. We have met cases where the application of sulphate of ammonia to barley reduced the yield of the clover, but in our experience this happens only when the land badly needs lime, and it is attributable to the increased acidity which sulphate of ammonia is liable to produce on such soils. The phosphate apparently had no action while the potash exerted a distinct residual effect, giving an additional 6 cwts. of clover hay in 1924 and 12 cwts. in 1923. The results indicate that potash should be applied to the clover if the barley crop has been good, unless it has already been given to the barley.

Inoculation of leguminous crops, especially lucerne.

Ever since 1890, when Hellriegel and Wilfarth discovered that leguminous plants live in association with micro-organisms inhabiting the nodules on their roots, efforts have been made to improve the growth of leguminous crops by adding the appropriate organisms to the soil. Some successes were obtained on the Continent, but the method failed in this country; the results at Rothamsted in 1906 and 1907 were not then considered sufficiently good to justify extension to farm practice.

There is no doubt, however, that for certain crops the principle is sound; the failure of inoculation in Britain must be attributed to the lack of compliance with the conditions necessary to success. During the past three years the whole subject has been re-examined in the Bacteriological Department.

The subject affords an admirable illustration of the way in which a practical problem of great importance remains unsolved, in spite of many empirical efforts, until the underlying principles have first been studied and a solid groundwork of definitely ascertained facts has been obtained.

The failure of inoculation in many cases has been traced to the circumstance that the organisms were already present in the soil, but some condition essential to the growth of the plant

https://doi.org/10.23637/ERADOC-1-116