THE INSTITUTE OF BREWING RESEARCH SCHEME.

THIRD REPORT ON THE EXPERIMENTS ON THE INFLUENCE OF SOIL, SEASON AND MANURING ON THE QUALITY AND GROWTH OF BARLEY, 1924.

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The field experiments have now gone on for three years, and are at present in their fourth; it is probable that by the end of the current season sufficient data will have accumulated to allow of some definite conclusions on the first of the three parts of the Sub-Committee's research programme, the influence of environmental conditions, soil, season and manuring, on the yield and quality of barley. It is proposed, therefore, at the conclusion of this season's work to reconsider the whole experimental plan with the view of proceeding to the further stage of making more extended malting trials with selected barleys, and finally of studying the third part of the programme: the relationship of the chemical composition of barley to malting and brewing value.

It is undesirable to prejudice this fuller treatment of the data by discussing the present season's results at length: little more than a record of the work will be given, with indications where the results agree with, and where they differ from, those of the preceding seasons. The agreement is close and affords gratifying evidence of the trustworthiness of the experimental results; the differences have thrown interesting light on certain apparent discrepancies and anomalies of the preceding two years.

The purpose of the experiments is to ascertain the influence of environmental conditions, such as soil, season and manuring, on the yield and quality of malting barley.

The experimental scheme comprises five plots, which are as follows:—

1. No manure.
2. Complete artificials: 1 cwt. sulphate of ammonia, 3 cwt. superphosphate, 1½ cwt. sulphate of potash per acre.
3. Artificials without potash: 1 cwt. sulphate of ammonia, 3 cwt. superphosphate per acre.
4. Artificials without phosphate: 1 cwt. sulphate of ammonia, 1½ cwt. sulphate of potash per acre.
5. Artificials without nitrogen: 3 cwt. superphosphate, 1½ cwt. sulphate of potash per acre.

The variety tested is Plumage Archer. The same lot of seed is used throughout all the experiments, being specially selected by Mr. W. Hasler, of Dunmow. In respect of both seed and manuring, therefore, the experiments at the different centres are strictly comparable. At each centre, however, the barley is grown in its accustomed place in the rotation, and receives the cultivation judged best by the grower; this involves differences between the various centres, which on purely technical grounds can be abundantly justified.

The centres were practically the same as in the previous year, excepting that Mr. Hill, of East Dereham, found himself unable to continue, and Sir Harry Hope had no suitable land in his barley break. Two new centres were added in districts where further information was wanted: Wye, Kent, and Porlock, Somerset. The list for this season was:—

Eastern Side.

1. Rothamsted Experimental Station, Harpenden, Herts.
2. Beds. Woburn Experimental Farm. Dr. J. A. Voelcker.
3. Kent, Wye. South-Eastern Agricultural College. R. M. Wilson, Esq., Principal.
4. Essex, Dunmow. W. Hasler, Esq., Barnston Lodge Farm (G. Bellfield, Esq.).
5. Suffolk. Howes Farm, Martlesham. Rt. Hon. E. G. Pretyman, Esq., Orwell Park.
6. Norfolk Experimental Station, Newton St. Faith.
7. Lincs. Wellingore. G. H. Nevile, Esq.
8. Lincs. Walcott. C. Bembridge, Esq.
9. Lincs. Cawkwell. Scamblesby. Louth. A. E. Davy, Esq.
10. E. Yorks. Beverley. J. H. Spilman, Esq., Gardham Farm.

Western Side.

11. Shropshire. Eyton-on-Severn. E. Craig Tanner, Esq.
12. Shropshire. Newport. Harper Adams College. Dr. C. Crowther.
13. Stoke-under-Ham. R. A. Clarke and Sons, Chiselborough.
14. Somerset. Porlock. T. H. Rawle, Esq., Court Place.

The season.—The season of 1924 was remarkable for its prolonged wetness, its lack of sunshine and its long-drawn-out harvest—one of the most protracted of recent years. It was the wettest of all the 72 years of which records exist at Rothamsted, being considerably worse than 1879, the worst year in the 19th century; indeed, three times already in the 20th century the 19th century has been beaten: in 1903, 1912 and 1924. A wet, cold winter was followed by a hard, dry February and a dry, sunny March, which allowed the land to be well prepared for barley: the drilling was done under peculiarly favourable conditions; indeed, many barley land farmers had never seen spring corn go in so well. The spring was late, but barley started well; it was checked in May, however, by persistent rain and lack of sun. The latter half of June and the first part of July were the only reasonably dry periods of the summer, and the nine days from July 8th to the 16th were all that could be called sunny and warm. The corn came on well during this period. August, though not wetter than the average, was showery and sunless: ripening was slow and uneven, and cutting was later than usual.

The yields at the various centres were less affected than might have been feared: in the main they were much like those of 1923. At Wellingore and Orwell Park, however, they were higher, while at Woburn they were less. The quality was on the whole better than last year.

The results.—There had been no cross cropping, and all the results are collected in Table I. Owing to bad harvest conditions it was impossible to get weighings or samples from Beverley. The figures from Orwell Park are approximations only: they are recorded in the tables, but omitted from the discussion: here also samples were taken for analysis and malting. Out of the remaining 70 plots, only two appear to present irregularities, and even these appear capable of explanation. Plot 5, which received potash and phosphates, but no nitrogen, gave somewhat lower yields both at Rothamsted and at Cawkwell than did the unmanured plots; this is contrary to the general behaviour. There is no doubt about the actual result. At Rothamsted the plots were triplicated, so that the error of the experiment is known: the differences were well outside the error. At Cawkwell the plots were large and were not replicated: a difference in any particular season might not be significant, but this result has been obtained in each of the three years, although the site of the plots has been changed each year.

The influence of nitrogenous manure on the yield of barley has been of the same order as in preceding years. The addition of 1 cwt. of sulphate of ammonia per acre increased the yield of total grain by 5 bushels per acre and of dressed grain by 4·3 bushels. For all the centres for the years of the experiment the average increase has been 5·4 bushels of dressed grain. This smallness of variation in effect has been pointed out in earlier Reports. There were increases in total grain at every centre, varying from 1·8 bushels at Woburn to 9·5 bushels at Rothamsted: there were also increases in dressed grain at every centre but Harper Adams. The gains at the different centres have been:—

Centre.	Bushels per acre.	
	Total.	Dressed.
Rothamsted	9·5	7·3
Woburn	1·8	1·7
Wye	2·0	0·4
Dunmow	5·0	4·6
Porlock	3·7	3·8
Newton St. Faith	5·7	5·7
Wellingore	5·6	5·6
Walcott	6·3	3·7
Cawkwell	8·6	8·6
Eyton	4·2	3·9
Harper Adams	4·6	—
Stoke	3·4	6·0
Mean	5·0	4·3

The effect of phosphate has been very small: on an average 3 cwt. superphosphate has added less than half a bushel to the crop. Only at Newton St. Faith, Walcott and Stoke was there any notable gain; at Newton St. Faith it amounted to 8·9 bushels: at Stoke it was 6·0 bushels of dressed grain and 3·7 of total: at Walcott 3·0 bushels of dressed grain and 3·7 of total. Elsewhere the gains were small and set off by losses of the same order. At Woburn there was an apparent gain through the omission of phosphate, which will be further studied.

The omission of potash has led to very interesting results. It will be recalled that in 1922 and 1923, potash had had but little effect on the yield, but at some centres it apparently depressed the yield. This year the depression has occurred at seven centres, including Rothamsted, on the triplicate plots, where there is no doubt about its significance. On an average, the result of adding 1½ cwt. sulphate of potash has been to reduce the yield by just under one bushel of total grain and 1½ bushels of dressed grain. There were depressions of 4 bushels at Rothamsted, of 3 at Woburn, Eyton, Porlock and Wye, and of 7 at Dunmow and Wellingore: this depression had been observed before at Wellingore. To whatever the adverse effect is due, it is something more clearly emphasised in some seasons than in others, and it was particularly marked in 1924. There have for some time been suspicions that potash might in certain circumstances be harmful to barley, but never before have so many observations on the subject been recorded. The data are being examined and the problem further studied in the laboratories at Rothamsted.

The effects on the yield resulting from the omission of phosphate and of potash are as follows:—

Centre.	Phosphate.		Potash.	
	Bushels per acre. Increase + or decrease −.			
	Total.	Dressed.	Total.	Dressed.
Rothamsted	+0·7	+1·2	+3·9	+4·6
Woburn	+9·3	+9·2	+3·0	+3·0
Wye	+1·5	+1·8	+3·0	+3·7
Dunmow	+2·1	+2·1	+6·8	+6·9
Porlock	+1·8	+1·8	+2·7	+2·7
Newton St. Faith	−8·9	−8·9	−5·3	−5·3
Wellingore	−0·9	−0·9	+7·4	+7·4
Walcott	−3·7	−3·0	−1·8	−1·5
Cawkwell	−2·2	−2·0	−4·9	−4·1
Eyton	—	—	+3·2	+3·6
Harper Adams	−1·3	−0·6	−1·2	−1·9
Stoke	−3·7	−6·0	−5·4	−6·0
Mean	−0·4	−0·4	+0·9	+1·1

These results, taken in conjunction with those of previous years, raise a number of points of interest to the barley grower, and they emphasise the need for revising the recommendations often made to farmers by agricultural experts as to the manurial treatment of barley.

Agricultural experts commonly base their advice on the Hoos Field results at Rothamsted. These have been analysed in great detail, first by Lawes and Gilbert and afterwards by Hall, and the deduction was drawn that the manuring of barley should be mainly, if not entirely, phosphatic, nitrogen being given only in certain circumstances and potash only rarely. This advice has been followed by the fertiliser manufacturers, and the compound manures sold for barley consist mainly of superphosphate and like substances.

Two of the most popular recommendations were:—

Barley after a straw crop. ½ to 1½ cwt. sulphate of ammonia; 3 cwt. superphosphate; no potash except on light soils only; then ½ cwt. sulphate of potash.

Barley after roots fed off. No nitrogen; 3 cwt. superphosphate; no potash.

The results obtained during the past three seasons do not bear out these recommendations; 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. superphosphate	0·9	(0·5)	1·2	0·5
1½ cwt. sulphate of potash	(1·1)	1·3	1·1	0·4

(Figures in brackets are increases and not decreases.)

It is interesting to note that on Hoos Field the application of 100 lb. sulphate of ammonia per acre gave an additional 5¼ bushels of grain during the first five years of the experiment (1852–1856), an increase agreeing well with the value 5·4 bushels in these experiments. This uniformity in action of nitrogenous fertilisers is very striking, and is in marked contrast with the behaviour of phosphatic and potassic fertilisers, the results of which cannot usually be predicted.

It is not proposed to anticipate the fuller discussion of next year, but the following facts are impressive :—

1. The addition of a nitrogenous fertiliser has on all but a few soils (mainly those known to be rich) led to an increase in crop which for all the tests averages 5·4 bushels per cwt. of sulphate of ammonia. Increases have been obtained whether the barley was grown after a straw crop, after roots fed off, or after potato and beet crops.
2. The use of 3 cwt. superphosphate per acre has given only a slight and unprofitable response after a straw crop or after potatoes and beets, and none at all after roots fed off.
3. The use of sulphate of potash has given small increases in crop after potatoes, less after roots fed off and none after a straw crop.

It will be seen at once that these results do not support the accepted recommendations. Nitrogenous manure has increased the yield even after roots fed off, and would in most cases have paid well; while the phosphatic manure which forms the basis of the usual manurial receipt, and is indeed the only thing recommended for barley after roots, gave no return on the average. Out of the whole of the 30 tests recorded, the farmer who had followed the standard recommendation would have gained in 4 and incurred a loss in the remaining 26. These tests are made on actual commercial farms on large plots often of an acre or more in size, and the possibilities of improving the manurial receipt are shown by the fact that, at the various centres, one or other of the schemes of manuring gave increases in crop representing actual cash values varying up to £5 or even £6 per acre. There are probably three reasons why the older recommendations should have proved unsatisfactory :—

1. Modern high-quality varieties of barley, such as the Plumage Archer, used in these experiments have stiffer straw than the older ones, and therefore can carry larger crops of grain without risk of being lodged. Thus they can safely receive more nitrogenous manuring.
2. The striking results of phosphates in the Hoos Field experiments have been too literally applied to ordinary farm conditions. The soil is heavy, and heavy soils usually respond well to phosphates; the effects are here further intensified by the circumstance that this soil is far more exhausted of phosphate than is usual. In practice, however, barley is usually grown on lighter soils, where the need for phosphates is not so pronounced.
3. Most farmers use liberal dressings of phosphates for their roots. The barley, therefore, can usually find in the soil most of what it needs; potash is also added in the rotation to the potato, mangold, sugar beet or to certain leguminous crops.

The valuation of crops.—This was done on February 25th, 1925, in the same manner as in previous years, by a sub-committee consisting of Messrs. Cherry-Downes, Lancaster, Reid and Wightman. The results are set out in Table III, and range from 50*s*. to 90*s*. per quarter, these values being considerably above those assigned for 1923, 39*s*. 6*d*. to 57*s*., or, for 1922, 30*s*. to 65*s*. It must again be emphasised, however, that the figures represent market values on a similar system of valuation, and they do not imply that the barleys of 1924 were correspondingly higher in quality than those of the previous year.

The most interesting comparison is between the samples that received nitrogenous manuring and those that did not. The addition of the nitrogen raises the yield, as is well known, but agriculturists usually fear that the valuation will be depressed; our experiments afford no justification for this fear. In none of the three seasons has the effect of the nitrogenous manuring on the valuation been more than slight: usually, indeed, it has somewhat increased the valuation, and in 1924 there was a depression only at Wellingore.

The influence of potash and of phosphates has again been slight. Omission of phosphates caused a slight reduction in valuation at Cawkwell and a larger one at Woburn; elsewhere there is no apparent effect. Omission of potash caused a reduction in valuation only on the very light sand of Orwell Park. Again these results do not agree with the current teachings of agricultural science. The usual recommendation in aiming at high quality is to give phosphates and to withhold nitrogen. These experiments, on the other hand, show that the use of nitrogenous manure, even after roots folded off, has not adversely affected the valuation of the barley (or in previous years 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 apparently not in 1923 or 1924. 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.

The value of the crops to the farmer.—This is set out in Table V, which has been calculated in the same way as in previous years. The cost of growing the crop at Rothamsted was £11 8*s*. 7*d*. per acre, as against £10 14*s*. 0*d*. last year, and on the lighter Woburn soil it was £6 17*s*. 0*d*.* per acre, while at the centre reported in previous years it was £7 3*s*. 5*d*., as against £7 2*s*. 0*d*. last year, the cost of manure being in all cases omitted.

Nitrogen content of grain and valuation.—The average nitrogen contents and the averages of the valuations of the samples from the different plots are given below. It will be observed that the nitrogen content is considerably less this season than it was in 1922 or 1923. The detailed results are shown in Tables II and III.

Porlock and Woburn are the highest in value, and also, with the exception of Cawkwell, the lowest in nitrogen content. The Cawkwell barley is, as usual, assigned a lower valuation than its nitrogen content would suggest; both in 1923 and 1924 the malting results accorded better with the nitrogen figure than with the valuation.

At the other end of the nitrogen scale the barleys of highest nitrogen content are, with the exception of Wye, the lowest in price. The Harper Adams sample was in very poor condition and receives a low valuation. There is only a slight connection this year between nitrogen content and valuation. This is explained partly by the condition of the barleys, which was an important factor in market valuation, and partly by the generally low nitrogen content of the barleys, as there is little evidence that a nitrogen content up to 1·6 per cent. is prejudicial to the malting value of English barley.

Centre.	Average Nitrogen per cent. on dry barley.	Average Valuation, shillings per quarter.	Previous Results Average Nitrogen content.	
	1924.	1924.	1922.	1923.
Cawkwell	1·223	64·2	1·52	1·49
Woburn	1·227	82·4	1·95	1·71
Porlock	1·303	88·8	—	—
Newton St. Faith	1·319	70·4	—	—
Eyton	1·361	66·8	1·92	1·70
Wellingore	1·421	71·0	1·79	1·44
Dunmow	1·463	69·0	1·77	—
Stoke	1·464	72·8	—	1·50
Orwell Park	1·517	67·6	1·51	1·93
Harper Adams	1·557	50·0	—	—
Rothamsted	1·563	63·2	1·62	1·61
Walcott	1·583	63·0	1·79	1·80
Wye	1·708	74·0	—	—

These results will be more appropriately discussed next year, when fuller data are available.

Influence of manuring on nitrogen content of barley.—As usual, the complete manure has lowered the percentage of nitrogen in the grain compared with no manure. Harper Adams and Walcott afford the only exceptions; at Harper Adams the percentage is raised, and at Walcott it is unaltered. Usually the lowered nitrogen percentage is associated with a higher valuation. Last year and in 1922 the omission of nitrogenous fertiliser usually lowered the percentage of nitrogen in the grain; this year it has done so only at two centres, Wye and Newport. Elsewhere it has been without effect or has actually increased the nitrogen. This increase occurred at Rothamsted, Orwell Park, Dunmow, Stoke-under-Ham, Woburn and

* Nothing is included here for general expenses which at the other centre amounted to £1 2*s*. 9*d*. per acre.

Table I.

Malting Barley Results, 1924.

*Dressed grain, bushels per acre.**

		Stiff Soils.		Medium Soils.			Light Soils.			Very Light Soils.		Chalk.		Fen.
No.	Treatment.	Rothamsted.	Dunmow.	Eyton-on-Severn	Wellingore.	Porlock.	Harper Adams	Stoke-under-Ham.	Newton St. Faith.	Woburn.	Orwell Park.	Cawkwell.	Wye.	Walcott.
1	Nil	24·65	27·9	29·27	43·3	21·76	30·42	27·0	32·7	21·3	12·0	40·2	51·8	46·0
2	All (a)	27·68	38·3	49·07	50·8	31·83	34·40	33·0	47·5	27·9	25·0	42·2	53·3	52·6
	(b)	26·78												
	(c)	28·00												
3	Less K	32·3	45·2	52·62	58·25	34·59	32·48	27·0	42·2	30·9	26·0	38·1	57·0	51·1
4	Less P	28·9	40·4	49·32	49·9	33·67	33·82	27·0	38·6	37·1	27·0	40·2	55·1	49·6
5	Less N	20·37	33·7	45·13	45·2	28·00	34·60	27·0	41·8	26·2	28·0	33·6	52·9	48·9
					Total grain : Unmanured = 100.									
1	Nil	100	100	100	100	100	100	100	100	100	100	100	100	100
2	All (a)	122	137	166	117	143	106	112	150	130	208	105	103	114
	(b)	120												
	(c)	124												
3	Less K	136	161	177	134	155	103	94	133	144	217	95	110	111
4	Less P	124	145	165	115	151	103	99	118	173	225	100	106	108
5	Less N	87	120	152	104	127	95	99	128	122	234	84	102	106
					Dressed grain : Unmanured = 100.									
1	Nil	100	100	100	—	100	100	100	—	100	—	100	100	100
2	All (a)	112	137	168	—	146	94	122	—	131	—	105	103	114
	(b)	109												
	(c)	114												
3	Less K	131	162	180	—	159	89	100	—	145	—	95	110	111
4	Less P	117	145	169	—	155	93	100	—	174	—	100	106	108
5	Less N	83	121	154	—	129	95	100	—	123	—	84	102	106

The figures for Wellingore and Newton St. Faith are for total grain, but the quantity of tail corn was negligible.
* 56 lb. bushels. (a) Complete artificials, sulphate of ammonia. (b) Complete artificials, muriate of potash. (c) Complete artificials, muriate of ammonia.

Porlock; at the last three centres the increased nitrogen content was associated with a lower valuation.

The omission of phosphatic fertilisers increased the nitrogen content at 7 out of 12 centres; it had also acted in this way in 1923, but not in 1922; only at 2 centres (Wellingore and Woburn) out of the 7 was there a fall in valuation. The omission of potash had a more marked action than in previous years and increased the nitrogen content at eight centres, but did not at more than two lower the valuation.

Influence of chlorides on barley.—The farmer has the option of using chlorides (or muriates) of ammonium and of potassium instead of the sulphates, and there are certain important technical differences between the two kinds of fertilisers. The comparison has been made at Rothamsted, and it gave such interesting results that it is being extended to certain other centres. In every test at Rothamsted the valuation of the grain has been raised and its nitrogen content lowered by using ammonium chloride instead of ammonium sulphate. This is shown by the following table:—

Season.	Valuation of Barley per qr. of 448 lb.		N. in grain; per cent. of dry matter.	
	Ammonium Sulphate.	Ammonium Chloride.	Ammonium Sulphate.	Ammonium Chloride.
	s. d.	*s. d.*		
1922	31 0	36 0	1·647	1·602
1923	57 6	58 0	1·544	1·485
1924	63 6	64 0	1·517	1·495

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.

Season	Ammonium Sulphate.		Ammonium Chloride.		Difference in favour of Chloride as against Sulph.
	Yield.	Money value per acre.	Yield.	Money value per acre.	
		s.		*s.*	*s.*
1922	36·0	136	35·7	156	20
1923	32·5	239	35·6	265	26
1924	29·8	238	29·7	249	11

TABLE II.

VALUE PER ACRE OF DRESSED GRAIN TO NEAREST SHILLING.

	Plot.	Rothamsted.	Dunmow.	Eyton-on-Severn	Well-in-gore.	Porlock.	Harper Adams	Stoke-under-Ham.	Newton St. Faith.	Woburn.	Orwell Park.	Cawkwell.	Wye.	Walcott.
		s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.	s.
1	None	185	234	241	390	237	227	250	278	213	101	326	479	302
2	All	221	326	406	450	357	214	305	427	314	219	343	494	414
3	„ less K	258	396	434	510	389	205	250	379	347	208	310	528	402
4	„ less P	231	354	407	436	378	212	250	347	371	236	316	510	391
5	„ less N	163	295	395	407	305	216	230	355	236	234	265	489	385

TABLE III.

VALUATION AND PERCENTAGES OF NITROGEN IN THE VARIOUS SAMPLES. NITROGEN PER CENT. ON DRY BARLEY. PRICE PER QUARTER.

	Dunmow.		Cawkwell.		Wellingore.		Eyton-on-Severn.	
	Per cent. Nitrogen.	Price.	Per cent. Nitrogen.	Price.	Per cent. Nitrogen.	Price.	Per cent. Nitrogen.	Price.
1. No Manure	1·564	s. 67	1·266	s. 65	1·424	s. 72	1·388	s. 66
2. Complete Manure	1·447	68	1·190	65	1·404	71	1·374	66
3. No Potash	1·438	70	1·253	65	1·403	70	1·361	66
4. No Phosphate	1·425	70	1·204	63	1·449	70	1·328	66
5. No Nitrogen	1·460	70	1·194	63	1·400	72	1·356	70
Average	1·463	69	1·223	64·2	1·421*	71*	1·361	66·8

	Stoke-under-Ham		Orwell Park.		Walcott.		Newton St. Faith.	
	Per cent. Nitrogen.	Price.	Per cent. Nitrogen.	Price.	Per cent. Nitrogen.	Price.	Per cent. Nitrogen.	Price.
1. No Manure	1·461	s. 74	1·591	s. 67	1·581	s. 63	1·334	s. 68
2. Complete Manure	1·403	74	1·407	70	1·586	63	1·286	72
3. No Potash	1·510	74	1·631	64	1·613	63	1·363	72
4. No Phosphate	1·495	74	1·433	70	1·560	63	1·324	72
5. No Nitrogen	1·451	68	1·521	67	1·575	63	1·289	68
Average	1·464	72·8	1·517	67·6	1·583	63	1·319	70·4

	Harper Adams.		Wye.		Porlock.		Woburn.		Rothamsted.	
	Per cent. Nitrogen.	Price.	Per cent. Nitrogen.	Price.	Per cent. Nitrogen.	Price.	Per cent. Nitrogen.	Price.	Per cent. Nitrogen.	Price.
1. No Manure	1·508	s. 50	1·741	s. 74	1·295	s. 87	1·230	s. 80	1·620	s. 60
2. Complete Manure	1·624	50	1·708	74	1·266	90	1·161	90	1·517	64
3. No Potash	1·631	50	1·748	74	1·326	90	1·173	90	1·540	64
4. No Phosphate	1·506	50	1·750	74	1·268	90	1·259	80	1·525	64
5. No Nitrogen	1·514	50	1·592	74	1·359	87	1·310	72	1·611	64
Average....	1·557	50	1·708	74	1·303	88·8	1·227	82·4	1·563	63·2

* For Plots 1–5.

TABLE IV.

MOISTURE PER CENT. IN GRAIN.

	Dunmow.	Cawkwell.	Eyton-on-Severn	Stoke-under-Ham.	Orwell Park.	Walcott.	Newton St. Faith.	Harper Adams	Wye.	Porlock.	Woburn.	Rothamsted.	Wellingore.
1. No Manure	19·44	20·32	17·75	20·22	19·32	18·50	18·16	17·12	19·50	17·85	19·26	16·10	17·88
2. Complete Manure	17·28	20·54	17·46	19·87	18·44	18·13	18·42	17·86	20·12	16·64	18·75	17·00	17·82
3. No Potash	18·24	19·94	17·54	19·94	19·26	18·30	18·70	16·82	20·72	17·60	18·56	17·28	18·00
4. No Phosphate	18·12	20·49	17·39	20·03	18·44	18·36	17·28	16·30	21·04	17·28	18·57	17·32	18·21
5. No Nitrogen	16·94	20·85	17·76	20·06	19·10	18·44	18·18	16·84	21·58	16·81	18·76	17·06	18·25 †16·76
Average	18·00	20·43	17·58	20·02	18·91	18·35	18·15	16·99	20·59	17·24	18·78	16·95	*18·03

* Average for Plots 1–5 only. † Surface sown after beet residues.

TABLE V.

1,000 CORN WEIGHT IN GRAMS CALCULATED TO DRY BARLEY.

	Dunmow.	Cawkwell.	Eyton-on-Severn	Stoke-under-Ham.	Orwell Park.	Walcott.	Newton St. Faith.	Harper Adams	Wye.	Porlock.	Woburn.	Rothamsted.	Wellingore
1. No Manure	39·1	36·9	39·2	36·4	42·7	42·8	33·0	39·2	40·5	38·6	37·6	40·6	39·2
2. Complete Manure	40·0	37·2	39·6	37·4	39·0	44·4	34·2	39·1	39·2	39·4	37·3	42·4	39·3
3. No Potash	39·2	38·0	40·0	38·0	41·2	43·1	32·8	40·6	38·8	38·9	35·8	42·2	40·9
4. No Phosphate	40·4	37·1	40·0	38·1	38·2	42·4	33·7	39·8	39·1	37·2	39·6	41·5	38·8
5. No Nitrogen	41·3	37·7	39·2	37·0	42·1	43·3	34·5	38·6	39·4	39·8	38·6	42·2	40·3 †38·9
Average	40·0	37·4	39·6	37·4	40·6	43·2	33·6	39·5	39·4	38·8	37·8	41·8	*39·5

* Average for Plots 1–5 only. † Surface sown after beet residues.

APPENDIX I.

Centres.	Particulars of soil, field and size of plot.	Previous cropping and manuring.	Date of sowing 1924. Rate of seeding.	Date of applying manure.	Date of cutting.	Date of carting.	Season.
EASTERN SIDE.							
Herts— Rothamsted Experimental Station.	Soil clay with flints. Heavy strong soil overlying chalk. Great Harpenden Field. $\frac{1}{15}$ acre in triplicate.	Winter wheat unmanured.	March 20th. 10 pecks per acre.	March 17th	Aug. 18th and 19th.	Sept. 11th	*See* p. 2.
Kent— South-Eastern Agricultural College, Wye.	Loam overlying chalk. "A" Field. $\frac{1}{5}$ acre in triplicate.	Mangolds: dung and complete artificials.	March 19th. 12 pecks per acre.	March 18th and 19th	Aug. 18th	Sept. 9th and 10th	Wet season generally. Particularly stormy at time of ripening. Heavy rain accompanied by very strong wind.
Beds— Woburn Experimental Farm. Dr. J. A. Voelcker.	Sandy loam, junction of Lower Greensand and Oxford Clay, deep, low lying, apt to be wet. Stackyard Field. $\frac{1}{4}$ acre.	Black winter oats unmanured.	March 11th. 12 pecks per acre.	March 11th	Aug. 12th	Sept. 1st	March, cold; spells of frost; rainfall slight. April early cold and dry, then hot followed by showery weather. May wet but warm. Fine and dry for 10 days before and 7 days after cutting, then dull and wet till date of carting.
Essex— Dunmow. W. Hasler, Esq. Felstedbury Farm.	Medium to heavy clay loam. Lane Field. $1\frac{3}{4}$ acres.	Wheat: 5 cwt. Seychelles guano. 2 cwt. kainit. 1 cwt. sulphate of ammonia.	March 17th and 18th. 10 pecks per acre.	March 15th	Aug. 25th	Sept. 11th	Dry spell giving excellent seed bed: then cold weather and 14 in. of rain out of annual 20 in. by June 10th.
Suffolk— Orwell Park, Ipswich. E. G. Pretyman, Esq.	Light sand on sand. Lineside Field. 2 of 4 acres, 3 of half an acre.	Colewort and mustard folded.	April 7th. 8 pecks per acre.	April 7th	Sept. 15th	Sept. 15th	Fine for seeding with heavy rain late May and continuing wet: cutting delayed by weather.
Norfolk— Norfolk Agricultural Station. St. Faith's, Norwich.	Light loam overlying gravel. Loke Piece Field. $\frac{1}{4}$ acre in duplicate.	Swedes: 3 cwt. superphosphate.	April 5th. 12 pecks per acre.	April 3rd	Aug. 20th	Aug. 28th	April cold with severe night frosts. May wet (3·8 in. rain). Later season very rainy, but harvested fairly well.

APPENDIX I—*continued.*

Centres.	Particulars of soil, field and size of plot.	Previous cropping and manuring.	Date of sowing 1924. Rate of seeding.	Date of applying manure.	Date of cutting.	Date of carting.	Season.
EASTERN SIDE—*continued.*							
Lincolnshire—							
Wellingore. G. H. Nevile, Esq.	Oolitic limestone. Lincoln heath light loam: about 8 in. soil. High Dyke Field. 3 acres.	Potatoes (heavy crop) 3 cwt. superphosphate. 1 cwt. sulphate of potash. 1 cwt. sulphate of ammonia. 1 cwt. nitrate of soda. 10 loads farmyard manure.	March 13th. 10 pecks per acre.	March 28th	Aug. 25th	Sept. 18th	February and March dry with night frosts when it rained till March 23rd; dry till April 13th; rainy spell till May 13th. Harvested under rainy conditions.
Walcott. C. Bembridge, Esq., Timberland Farm.	Black fen soil with clay and silt subsoil. 2 acres.	Winter oats unmanured.	March 10th and 11th. 12 pecks per acre.	March 10th and 11th.	Aug. 20th	Sept. 12th to 13th.	Exceptionally rainy in late April and May. Stormy and unsettled during whole summer.
Cawkwell. A. E. Davy, Esq.	Chalk wolds, red rather heavy loam overlying chalk, 6-12-in. down. Middle Walk Field. 2 acres.	Turnips folded	March 25th. 10 pecks per acre.	March 27th	Aug. 25th	Sept. 15th	Plenty of rain, little sun. Good before cutting. Showery weather till carting.
WESTERN SIDE.							
Shropshire—							
Harper Adams College, Newport.	Sandy loam overlying lower Trias. Lower Foxhills Field. ¼ acre.	Swedes: 8 tons farmyard manure. 4 cwt. basic slag. 3 cwt. steamed bone flour. 1 cwt. sulphate of ammonia. 2½ cwt. kainit.	April 8th. 10 pecks per acre.	April 8th	Sept. 2nd	Sept. 29th	Very little rain till April 18th, after which abundant rain.
Eyton-on-Severn. E. Craig Tanner, Esq.	Trias red medium, loam gravelly. Allens Field. 1 acre.	Swedes: 6 cwt. bone meal.	March 14th. 9 pecks per acre.	March 28th	Aug. 19th	Sept. 15th	Wet season generally. Rain before harvest and showery throughout.
Somerset—							
Stoke-under-Ham. Chiselborough. Messrs. R. A. Clarke & Sons.	Inferior Oolite light sandy soil. North hill Field. 1 acre.		Feb. 19th. 8 pecks per acre.	Feb. 29th	Aug. 17th	Aug. 25th	Unusually rainy in May.
Porlock. R. H. Rawle, Esq.	Stonebrash derived from Red Sandstone. Eight acres Field. ¾ acre.	Winter oats followed by catch crop of turnips folded.	March 20th. 10 pecks per acre.	March 20th	Aug. 25th	Sept. 3rd	Cold and dry early in April followed by much rain. Cut in rain but stacked and carted in fine weather.

NOTE.—There are 4 pecks to 1 bushel.

APPENDIX II.

Farmers' and Rothamsted Staff's Report on Growing Crops.

Rothamsted.—Summary of Season's Observations.

The barley went in well and progressed favourably until the rains of May. Plots 1 and 5 (no manure and no nitrogen) looked lighter in colour, and Plot 3 (no potash) darker than the completely manured. Plots 1 and 5 lagged behind 2, the completely manured plot, throughout the season in all characteristics, height, leaf emergence, leaf width, total height, shoot height and ear height. Plot 1 was the less advanced of the two in total height till June 16th and in shoot height and ear height till August 2nd, after which the No Nitrogen Plot No. 5 was the less advanced of the two. Plot 3 (No Potash) lagged behind 2, the complete manure, till July 1st, when it overtook Plot 2 in total and "shoot" height and later on in ear height. The grain samples of Plots 1 and 5 were the highest in moisture content throughout the latter end of the growing season and in the sheaves.

W. Hasler. Dunmow. 1924.

May 27th.

No plot looks really well. No. 1 very yellow after the heavy rainfall.

June 10th.

Plot 1. Yellow, poor tillering, good height compared with barley generally, 5½ leaves. Roots trying to put out adventitious branches high up coleoptile. Poor and not many fibrous roots. Ear formed.

Plot 2. More tillering (3 or 4). Stouter shoot and broader leaf. 3 nodes easily discernible, considerable lengthening of inter-nodes; colour better; fibrous root system more developed.

Plot 3. Tillering as 2. Leaves shorter. Nodes less marked. Roots as 2. Thinner in shoot perhaps.

Plot 4. Stands perhaps a little less well than 2, but tillers and roots well developed. 3 nodes quite easily found.

Plot 5. Almost as poor as Plot 1. Leaf diminished. Nodes poorly developed. Internodes short. Yellow in colour. Roots less fibrous than 2, better than 1, showing surface spreading.

General.—Good, considering season. Previous manuring probably helped. The N dressing effective even in this abnormal season.

Orwell Park. 1924.

May 28th.

Plot 4 appeared the best, closely followed by Plot 3. Plot 5 the poorest.

June 11th.

Plot 2. Growth fair, but inclined to be spindly. Colour poor. Roots showing signs of water logging. Tillering good 3 to 4, but latest tillers dying, leaves fairly broad.

Plot 4. Slightly less leaf than 2. Shorter in internodes. Roots as 2, tillering good, colour equal to 2. Stands a little straighter than 2.

Plot 5. Much thinner, drill rows visible. Tillering normal, roots not water-logged. Leaf small, less dying-off of leaves. Only just beginning to shoot.

Plot 3. At present a good-looking crop compared with the rest. Tillers and roots as 2. Good broad leaves and internodes.

Plot 1. As 5, roots less fibrous, leaves less spreading, no nodes.

General.—Looking poorer than that sown a month ago.

St. Faith's. Norwich. 1924.

May 23rd.

Plots 2 and 1 show the most marked contrast. The difference is greater than in most years at this stage.

June 11th.

Plot 1. The poorest plot of all; poorer than 5. Drill rows plainly visible.

Plot 2. Good plot, but not very markedly better than other plots receiving Nitrogen.

Plot 3. Less leaf, less roots than 2 or 4. Colour good. Straw soft, drill rows visible. Commencing to shoot.

Plot 4. Good leaf, roots fairly fibrous, tillering good. Colour superior to 5, but shoot not noticeably superior, 2 nodes observable.

Plot 5. Colour fair. Root poor, 2 nodes, good tiller, long internodes.

General.—The effect of Nitrogen has not shown markedly.

August 19*th*.

Plot 1. Straw 17 to 23 inches. No sign of lodging. Slight unevenness in ear emergence.

Plot 2. Straw 27 to 30 inches; well developed and even in ear, no lodging.

Plot 3. Straw 25 to 30 inches. Tendency to lean. Grain not so regular in ripening.

Plot 4. Straw 23 to 27 inches, no tendency to lean. Good plump grain.

Plot 5. Straw 18 to 24 inches. Ears unevenly developed.

Wellingore.

May 28*th*.

Plots with nitrogenous manure showing up better than in previous years owing to good growing season.

June 12*th*.

Plot 1. Thin, poorer than 5, leaves narrow and less spreading. Root poor, height 15 inches, internodes 2 inches, nodes 1 or 2 rarely. Tillering weak, shoot soft, 5 leaves.

Plot 2. Height 23 inches, leafy broad blades, long internodes 4 inches, 3 nodes. Good fibrous roots, 5½ leaves. Ear well forward. Stem firm.

Plot 3. Height 24 inches, leaf broad, no colour difference. 3 to 4 tillers. 2 to 3 nodes. Roots better than 5. 5½ leaves, rows not visible.

Plot 4. Height 21. Colour good, leaf spreading in habit; 2 to 3 nodes, internode 3 inches. Good roots. As much leaf as 2.

Plot 5. Height 19 inches. Leaf broad, 2 to 3 tillers. Good colour. Only one node. Stem slight. Roots fair, drill rows visible.

August 18*th*.

The most marked difference in ripening was the delay of a few days in the No Potash plot (Plot 3).

Timberland Fen, Walcott. 1924.

May 25*th*.

No difference visible.

June 12*th*.

Plot 1. Very good plot. Colour good; broad leaf, no drill rows visible; 5 to 6 tiller; 5 leaves. Roots only moderately fibrous, 2 to 3 nodes with long internodes.

Plot 2. Better in all ways than 1. Very firm straw. Few shrivelled leaves. Ear nearly breaking.

Plot 3. As 2, but a little more upright in habit, less spreading. Thinner straw. Ear less marked. Excellent in growth and colour. Roots equal to 2.

Plot 4. Very similar to 3, with poorer roots.

Plot 5. Very much as for 1. The most uneven of all.

General.—Potash and phosphate shortage show slightly.

Cawkwell.

June 13*th*.

Plot 1. Thin, drill rows visible, tips of leaves dying off, roots poor and coming off coleoptile. Soft stem and short. 3 tillers.

Plot 2. Not very good plot, leaves dying at tip. Less vigorous than plot 4. Stem thin; starting to shoot; 4 tillers. Roots fair.

Plot 3. Marked falling-off from 4. Taller than Plots 1 or 5, but no more leaf. Leaves 3½, one node only. Soft stem. Roots poor. Colour good.

Plot 4. The best of the series, colour good. Broad leaf, 1 node only, but longest stem. 3 to 4 leaves, 4 tillers, roots not very fibrous.

Plot 5. Colour good, 3 to 4 leaves, narrow, not yet shooting, nodes nil, tillers 3. Roots poor.

Harper Adams Agricultural College. 1924.

May 30*th*.

Wet weather has made it impossible to judge between the different treatments.

June 18*th*.

Plot 1. Uneven plot. Some tillers dying off. Drill rows visible. Standing very straight. Leaves yellowing markedly. Stem soft; 3 nodes.

Plot 2. Colour very good, growth good, 4 nodes; leaves all green. Roots well developed. Stem still soft.

Plot 3. Less hardy appearance all round than 2. Narrower in leaf. Yellowish colour in leaf.

Plot 4. Less leafy and tall than preceding. Light in colour. Drill rows visible. Stem soft.

Plot 5. Drill rows visible, leaf poor; colour yellow, similar in appearance to 4; better than 1.

Eyton. 1924.

May 24th.

No difference visible.

June 19th.

Plot 1. Poor in leaf and less mature than 5. Turning yellow, short in leaf. No shooting visible; soft in stem. Drill rows visible.

Plot 2. Appears the leafiest of all. Greener than 1. One whole above the ear in sheath. Stronger than 1 in stem.

Plot 3. Colour good as 2. Tillering 2, leaf medium broad. Roots only moderate.

Plot 4. Not as dark as 3, otherwise very much the same. Leaf a little narrower. Some ears already out.

Plot 5. Drill rows visible. Evidence of dead tillers.

Chiselborough, Stoke-under-Ham. 1924.

May 27th.

Plot 2 the best. Plots 1 to 5 show little difference.

June 23rd.

Plot 1. Quite a fair plot, but behind the others. Weak in straw, poor in tillering.

Plot 2. The best plot in all ways, straw leaf and tiller; and good colour 5–10 per cent. ears out.

Plot 3. Growth good, green, leaf well developed. More ears shot than other deficiency plots. Except for ear development not better than 4.

Plot 4. Glaucous in colour. Growth good. Slightly yellow in lower leaves. More leaf than 1. Ears emerging.

Plot 5. Poor in tillering, yellow in colour. Awns just emerging; slender straw.