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Malting Barley

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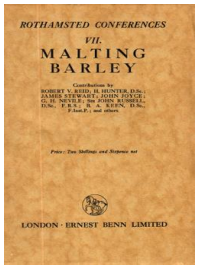

VII. Malting Barley

Sir A. Weigall

Sir A. Weigall (1929) *VII. Malting Barley ;* Malting Barley, pp 1 - 50 **- DOI: https://doi.org/10.23637/ERADOC-1-200**

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MALTING BARLEY

BEING THE REPORT OF A CONFERENCE HELD AT ROTHAMSTED ON MARCH 15TH 1928 UNDER THE CHAIRMANSHIP OF

LT.-COL. SIR ARCHIBALD WEIGALL
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1928
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WHAT BARLEY BUYERS WANT

By ROBERT V. REID
Past-President Institute of Brewing

To cry for the moon is to crave what is entirely beyond one's reach! I shall not go so far as to say that the buyers of malting barley crave the impossible, although some of my audience may think they come very near it. I am sure that you do not wish me to-day to expound empirical views on the quality of malting barley, although we all know that to a very great extent they rule the minds of the buyers. I feel sure you expect me to say something of more practical value. You will agree with me that in recent years we have embarked on serious practical and scientific research work to probe the mystery of quality in malting barley ; if the results up to the present time do not yet guide the buyer very completely in his selection, there are one or two principles which are emerging, and the future is full of encouragement. As a Past-President of the Institute of Brewing I naturally know more of the details of our own research work, but as on our Barley Committee this experimental station, the N.I.A.B. of Cambridge, and the leading seedsmen's associations are fully represented, we can be satisfied that every interest is pulling its weight ; and on behalf of the Institute I would acknowledge the debt of gratitude we owe to all who contribute to our search after knowledge. I am sure my colleagues would wish me to take the opportunity I have here at Rothamsted to express our appreciation of the services of the director of this Agricultural Trust, Sir John Russell, in presiding over the deliberations of our Barley Research Committee of the Institute of Brewing.

The first principle which has emerged from the more enlightened policy of to-day is the necessity and usefulness of a very close co-operation and friendship between the fermentation industries and agriculture. A conference such as this we are attending to-day is sufficient answer to those who maintain that a natural enmity must always exist between agriculture and the brewing and distilling industries, and confirms my contention that a very close mutual friendship with farmers is the first answer to "what the barley buyers want." And the second answer is, that we buyers, recognizing the great decline in the acreage under barley in the last twenty-five years, want to find ourselves in the position to purchase increased quantities of British malting barleys. The reason is obvious. Increased output means more profitable business to ourselves and to this branch of agriculture, and the producers and consumers of British malting barley claim that their demand for a reduction of the present beer and whisky duties is reasonable and fair.

I must not take up your time with a lengthy exposition of the reasons why I opposed the proposed tax on imported malting barley,

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which is largely supported by, and popular with, farmers; they centre round the changed conditions of the brewing industry, the lower gravity of our national beverage—largely a matter of taxation—and the demand of the public under existing taxation prices for a bright and clear bottled "cup" that they hope may cheer, but certainly will never inebriate. Now in the manufacture of such a beverage a proportion—small, I am glad to say—of foreign sun-dried barley is an absolute necessity, and in a brewer's mash a proportion of husky barley for drainage—small again, I am glad to say—is another necessity, and I have no hesitation in saying that, tax or no tax, that proportion of foreign husky malting barley must continue to be used.

Now I have dealt with my first two answers to the title of my paper; perhaps they are more abstract answers than may have been expected, but when I sum them up—(1) Co-operation and friendship with agriculture; (2) A large increase in our purchasing power—I believe they would materially ameliorate a certain depression which we know exists among the farmers who give of their best to supply buyers of malting barleys.

When I turn to actual practical requirements as to quality in malting barley I am on very difficult ground, and can only try to "postulate" some views which may guide buyers from our knowledge so far as our research and practice has at present taken us. "Postulate," I think, is the best word to use, for its dictionary definition is "a proposition assumed without proof," and probably you will agree that, while we have passed some milestones on the road to "proof," we are still far from our journey's end.

The standard required to-day to satisfy buyers with their efficient organization, practical and scientific, is a very high one, but that is fully appreciated, for efficiency prevails on the farm, as in the malt-house and laboratory. It has been said before that "quality is indefinable," and those who have attempted to define its meaning seldom arrive at agreement. My own firm carries on its operations in the North, South, East and West, and, translating that into malting barley terms, I might say, in the districts where Goldthorpes, Standwells, Chevalliers, Archers, Spratts and Hybrids all present their rival claims to superiority. It would be futile for the maltster buyer to attempt to persuade the brewer in some particular district radically to change his practice where he gets satisfactory results from one seed variety because in another district some other variety appears to be superior. All the same, the experimental work that is being carried out so exhaustively to-day is going to supply us with much knowledge, and will probably prove that many of our accepted standards are false, and the progress of agricultural science may shake our most rooted convictions.

The grower must remember that while there is a class of buyer that requires the finest malt as regards appearance (combining quality, of course) there is another class quite satisfied with a sound malt, from

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which the required results can be obtained, without that exceptional bright colour and appearance required by the former. Therefore growers in districts where sound quality is the rule, without the exceptional colour or brightness desired by some, can carry on with confidence, for their barleys will be required and will be selected by many buyers.

The idiosyncrasies of buyers will always remain, and if they are not too irrational they are valuable, for they will always be an aid to growers by helping them to dispose of the variable crop which we must always grow under the conditions of the British climate.

Therefore, to dream of a standardized barley seed producing a standardized quality is hopeless, but, in its hopelessness, probably a fortunate limitation of what might unthinkingly be aimed at as perfection.

What buyers want generally in our present state of knowledge is barley of the Chevallier class, grown on *barley-land*, well ripened, of good shape, uniform, carefully threshed, thoroughly sound, with a nitrogen-content not exceeding, say, 1·6, free from weed contamination, and capable of producing first-class malt.

It might be worth while to tell you *what we do not want—i.e.* hard, steely, heated, badly threshed (skinned and broken corns), grown corns, high nitrogen. It may be useful to set out these general requirements in more detailed form as follows :

(1) Careful selection of pure seed.

(2) Careful manuring and treatment of the land.

(3) Where possible, fields should be weeded during the growing period of the barley ; this would largely reduce the amount of objectionable extraneous matter in the barley when it is threshed.

(4) The barley is usually greatly improved after being in stack.

(5) Very great care should be taken in the stacking of barley to see that it gets proper aeration, so that there is no risk of the grain heating. Farmers do not generally realize that slight heating condemns the barley for malting purposes equally with serious heating. The presence of objectionable weeds (see paragraph 3) is very often the chief cause of a stack heating.

(6) *Threshing.*—The threshing machines should be set with great care, and watched continually during the process to prevent the barley being damaged and skinned.

(7) *Roof Corn* should be excluded, as, if mixed in with the bulk, the value is always seriously depreciated.

(8) Where possible, barleys should always be baulked before delivery, and the sample for selling purposes drawn from all over the bulk, thus being thoroughly representative.

(9) In the case of a farmer sacking up his barley direct from the threshing machine, and not being in a position to baulk it, his sample for selling purposes should be drawn from each sack.

(10) Farmers should not be tempted to sell on the best sample, but on a fair average, as, when maltsters examine every sack on arrival at

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their maltings there is no possible chance of any inferior barley escaping their notice.

(11) In the event of a farmer having more than one field of barley, it is advisable to keep the barley from each field separate, and to sell it on individual samples. It is possible that all the fields were originally sown with the same seed, but it cannot be taken for granted that each field when harvested will be equal in quality.

(12) Established confidence and a reputation for good deliveries will always secure a preference and the top market-price.

It would appear that of recent years our research work, combined with practical experiments and practical working, has established the importance of the nitrogen-content in the barley as a test of satisfactory malting quality, and much information and assistance is, and will become, available to the barley grower as the work proceeds.

I need not in this paper give you tables to prove the more satisfactory malting results from barleys with low nitrogen-content, these are available in the published analytical reports of the Institute of Brewing Research Work, and very interesting records are given by Lancaster in a paper read by him to the N.I.A.B., and published in that Institute's journal in 1926. In this paper Lancaster dealt with the subject exhaustively, and so fully covered the ground generally as to quality in malting barley that I would commend a study of it to those who would desire to take the important subject of my paper further than I am able to do to-day, for I am sure I have taken my full share of your valuable time, and, having been requested to talk to you on this subject, I have judged that it would not be in the real interest of the growers, the scientific research workers, the maltsters and the brewers if, in this period of transience from darkness to light, I were to dogmatize more particularly than I have done on "what the barley buyers want."

MALTING BARLEY: OLD AND NEW VARIETIES

By H. HUNTER, D.Sc.

National Institute of Agricultural Botany, Cambridge

Varieties of cereals furnish suitable material for research on many lines, for they reflect the character of agricultural and consequently of human evolution in no uncertain manner. The diversity of form and adaptability to environment they display are matters of considerable interest to the botanist and evolutionist alike, but this meeting is mainly concerned with their economic side, and perhaps more particularly with varieties as we know and use them to-day.

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I might present the subject of malting barleys to you merely as a record of varieties, but it may be more useful if I treat them as stepping-stones in a line of progress.

Although there are many references to barley in old agricultural works, the comparative value of varieties on a quality basis does not appear to be of serious moment until within comparatively recent times. To-day the variety question is a many-sided one. There are two large interests involved—that of the producer, the farmer, and that of the maltster and brewer—and our concern as plant breeders and agriculturists is to endeavour to harmonize these interests.

The farmer's interest does not differ in essentials from that of other business, it is merely a remunerative financial return per unit area. This may be achieved by a high yield per acre, or by lower yield combined with a higher quality sufficiently remunerated to compensate for lower yield. Whether the latter course is practicable depends on a number of circumstances, but what is certain is that for the generality of conditions a combination of high yield and high malting quality is the goal to aim at. I shall endeavour to show later that these two attributes of what we may regard as an ideal variety are not antagonistic and can be obtained in combination.

With a general increase in soil fertility, proceeding from the introduction and use of artificial manures and a greatly increased cost of production, it has become essential to pay greater regard to the character of the straw of all our cereals, and more particularly that of barley. This is a pressing agricultural aspect of the variety question.

A good variety of barley should also possess a wide range of adaptability to soil and climatic conditions, for a line of general policy with this cereal should be a strict limitation of the number of varieties in use. In no other manner can we hope to obtain that uniformity of character and freedom of mixture of different sorts that the maltster and farmer desire. The brewers' requirements have been dealt with already. Whilst in the main they involve a high starch or, inversely, a low total nitrogen-content in the grain, there appears to be some difference in less readily defined qualities in the requirements of different breweries. It is hoped that the malting and other investigations now being carried out by the Institute of Brewing will eventually supplement our knowledge on the values of home-grown malting barleys. At the moment they are perhaps not sufficiently advanced to use in other than a tentative manner. Most of the information I shall present on this aspect of the question is derived, therefore, in so far at least as older varieties are concerned, from a series of experiments made in Denmark by the Royal Agricultural Society of that country in collaboration with the Carlsberg Brewery, Copenhagen, and from a similar series carried out in Ireland by the Department of Agriculture there in collaboration with Messrs A. Guinness, Son & Co., Ltd. To what extent these results are applicable to conditions in this country

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remains to be seen, but the fact that the variety finally decided upon for use in Ireland, where it is now grown on 90 per cent. of the barley area, has already attained a high position of merit in this country indicates a strong possibility of a close correspondence in the final position.

Cultivated even to-day, in isolated patches, there are to be found a number of narrow-eared barleys under the names of Scotch Common, Old Irish, Old Cornish, Early Welsh, Nottingham Long Ear and Old Wiltshire Archer. These conform tolerably well with the three sorts, "Rath-ripe," "Middle Ripe" and "Late Ripe"—barleys that Lisle states in his *Observations on Husbandry*, 1757, were in general cultivation in the eighteenth century. The tenacity with which the cultivation of some of them is still persisted in indicates the possession of special features of adaptation to definite conditions of environment. Old Irish, for instance, is still grown in parts of Co. Wexford. It is early-ripening, and this feature is probably the reason for its use on the heavier soils of that county, for in no other respect is it a desirable variety. Such tests as have been made with these varieties indicate that they are inferior in both yield and quality to more recent introductions. They are also, as a rule, weak-strawed.

Just a little over a hundred years ago a narrow-eared barley, named after its propagator, Dr Chevallier, made its appearance. We have no knowledge of its ultimate origin beyond what has been published by Dr Beaven. In course of time various selections of Chevallier—such as Webb's Kinver Chevallier, Hallett's Pedigree, etc.—appeared, but they all resemble one another closely, and all arose, most probably, from the original barley picked out by Dr Chevallier.

Chevallier marked a very definite advance on the narrow-eared varieties in use prior to its introduction, from which time until about twenty years ago it was grown extensively in the British Isles and on the Continent. In the appearance of the grain, in quality and in yield, it was much superior to the other narrow-eared sorts I have just mentioned. As brewing material, Chevallier long held deserved favour with the brewers. Its eclipse was brought about by Archer, to which barley it was found inferior in yield, in strength of straw and, finally, with accumulating knowledge, in malting quality.

The origin of Archer is obscure; until recent years it was grown in an unselected condition in the East and South-East of England, where it is believed to have existed for a long time. It bears a strong likeness to Lisle's "Late Ripe" barley, and it is considered by some authorities to be the present-day representative of that sort. The record of Archer during the past twenty years marks it as a variety of outstanding merit. Agriculturally, it possesses several most desirable features—high grain productivity, short straw, standing well under many conditions; short neck, no loss of ears becoming detached from the straw, either before or during harvesting. Archer can thus be left standing until it is

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completely ripe, and is the easiest of all varieties to thresh. The grain, however, does not possess the attractive colour or general appearance of Chevallier.

In Denmark, and later in Ireland, Archer enjoyed unqualified success, being proved superior in yield to Chevallier and all other varieties against which it was tested. Furthermore, except in districts where it was too late in ripening, Archer exhibited a wide range of adaptability, and some evidence of a higher relative potentiality on less fertile soils.

These facts enabled it to be used as a standard of comparison for other varieties, and many of us have acquired the habit of considering both old and new varieties on this basis.

For a time the valuation of samples in Denmark was based on the physical appearance of the grain, points being allocated to form, colour and quality. On this basis, Archer—or Prentice, as the barley was known in Denmark—mainly on account of the duller colour of the grain, actually occupied an inferior position. *In the brewery, however, the total nitrogen-content of Archer was found to be lower than that of all other varieties, excepting Goldthorpe, and this corresponded with a higher quantity of extract on malting.* The Irish trials confirmed those obtained in Denmark on this point.

Proceeding from the results of this work, a good many pure-line selections were made from the Archer barley, which previously existed as an unselected population. To the selection and distribution of these pure lines the increased average yield of barley in Denmark from 1890, and in Ireland from 1900, may be mainly attributed.

Coming now to broad-eared barleys, the only older form meriting attention here is Spratt. Spratt barley in early growth is characterized by a long, narrow leaf and abundant tillering, features to which it probably owes its name—for Sprat, Sprit or Sprot are Scotch words used for any coarse kind of reedy grass growing on marshy ground. From references found in Fitzherbert's *Boke of Husbandrie*, 1523, we gather that Spratt barley is an old-established form. It is still grown to a small extent in the Fens, where it yields large crops of grain—not, however, of the best malting quality. A striking feature of Spratt is its strong, upright straw. On this account it has been utilized as a parent in certain new hybrid barleys, and this is its chief claim to notice here.

The next broad-eared variety is Goldthorpe, which was found in a field of Chevallier so recently as 1889. How it arose, or whether it has any connexion with the Continental broad-eared forms, I cannot say.

Goldthorpe has a high grain-yielding potentiality, but it is characterized by a long "neck," and the ears are extremely liable to become detached from the straw, especially when the crop is allowed to become fully ripe, as it should be, to obtain the highest quality. The unfortunate bearing of this characteristic on the fortune of the variety will be appreciated when I add that Goldthorpe was, and still is, one of the best

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quality barleys in existence. In both Denmark and Ireland it proved excellent malting material, and invariably superior to Archer by a small amount.

In yield of grain Goldthorpe is usually inferior to Archer, but the degree of inferiority varies with the incidence of loss, due to causes just indicated.

In common with many other broad-eared barleys, Goldthorpe is better suited to the richer and heavier soils than to those of a lighter, gravelly nature, on which narrow-eared barleys flourish. It also requires plenty of moisture to produce the best yields and quality: as it ripens from a week to ten days earlier than Archer its cultivation is possible well into the North of England and the Lowlands of Scotland.

In the light of the Danish and Irish experiments, and, to a large extent, in that of general experience in this country, the position reached at this point may be summarized briefly as follows: on the generality of soils, and almost independently of season, Archer is the most remunerative variety for the farmers to cultivate. Goldthorpe exhibits a greater susceptibility to the effect of soil and season. In most seasons Goldthorpe produces grain of slightly higher malting quality than Archer, but in general this difference is insufficient to permit of a difference in price sufficient to compensate for deficiency in yield.

These findings, of course, postulate a close adherence to quality, as determined by the total nitrogen figures and by the actual quantity of extract obtained on malting. They may not allow sufficiently for difference in physical appearance and colour, and they certainly do take into consideration the *appearance* of the malt, which is, I gather, not an extremely important factor in malt valuation. But this is an issue quite outside my province, and, as it is still a matter of experience, evidently one difficult to define, although its importance is unquestionable.

So far we have concerned ourselves with what may be called natural varieties, but, with the development of the study of heredity, as related to both plants and animals, the last twenty-five years has witnessed extraordinary efforts to synthesize agricultural plants, amongst other things. As a result, interest in the barley crop is now focussed on a series of new varieties, which represent efforts to reconcile still more closely the interests of the farmer and the brewer, or, in other words, to combine higher grain-yield and reduced risk and cost of harvesting with higher malting quality.

One of the first hybrid barleys to be placed on the market was Standwell, which was introduced by Messrs Garton. Standwell is characterized by a large and whitish-coloured grain. In the Danish and Irish experiments it proved inferior to Archer in both yield and quality. Two features, brittleness of straw and a high degree of "blindness," militate against high yield in this variety. To secure the crop against loss through ears breaking off the straw it is necessary to cut it before it is

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fully ripe—a procedure which must inevitably react detrimentally on the quality of grain.

Standwell is early-ripening and proves valuable on heavy soils and in late-ripening districts.

Other varieties—such as Maltster, Brewers' Favourite, Invincible, all very similar to Standwell—appeared later, but have now disappeared almost completely from cultivation.

The next hybrid variety to claim attention is Plumage-Archer, which was produced by Dr Beaven in 1905. Plumage is a broad-eared barley, closely resembling Goldthorpe in all features, and the Archer used in the cross was a pure line selected by Dr Beaven. Recognizing the high quality and yield of Plumage, and the high yield and almost equally good quality of Archer, Dr Beaven set out to attempt to produce a broad-eared barley with the shorter neck and, consequently, the immunity to loss of ears found in Archer, and the variety we know to-day as Plumage-Archer is the result. The manner of selecting this particular form, and of later forms—such as Beaven's 1924—has been described by the producer.

In yield of grain and in malting quality Plumage-Archer is outstandingly good, and furnishes an example of successful synthetic effort, and is a tribute to the long and enthusiastic work of its producer.

Like most broad-eared varieties, Plumage-Archer shows a preference for the rather heavier soils. It is relatively early-ripening.

Archer-Goldthorpe (451) is another broad-eared variety, and is the result of an attempt to improve Goldthorpe by reducing the length of "neck." In length of straw and of neck this hybrid resembles the parent Archer. Unfortunately the yield is not equal to Archer, but the quality of grain is invariably good, and probably slightly superior to the Plumage-Archer standard. The variety is early-ripening, and this feature, combined with a short, stiff straw, indicates the possibility of successful use on heavier soils and in late districts. Following, we come to Spratt-Archer, which had its origin in the following circumstances. Although Archer proved so successful in Ireland, it exhibited two features which came to be regarded as undesirable. In seasons characterized by abundant and rapid vegetative development in the spring the straw was inclined to be weak, and thus liable to "lodge." Again, in wet seasons and in seasons of deficient sunshine—conditions perhaps more generally prevalent in Ireland than here—it was late in ripening.

For several reasons it was considered desirable to adhere to the use of a narrow-eared variety in Ireland, and for a time the forms of this type—secured from a cross with Goldthorpe—were studied, but none was sufficiently promising to justify extended cultivation.

Of all native varieties Spratt possesses the greatest strength of straw, and, although the malting quality of the variety is below the average, it was decided to try it as a parent. From this cross a narrow-eared form

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was finally selected, and from its produce a series of further selections made, of which No. 6 is the one now in general use.

The average yield of grain per square-yard plot, in 1918 and 1919, of Archer and Spratt-Archer, was :

	1918	1919
	17 comparisons	*35 comparisons*
Archer . . .	211 grammes	185 grammes
Spratt-Archer, 37s. 6d.	225 ,,	233 ,,
	14±7	48±5

whilst the total nitrogen figures for the same plots were :

	1918	1919
Archer	1·73 per cent.	1·46 per cent.
Spratt-Archer, 37s. 6d. .	1·53 ,,	1·27 ,,
	0·20±·012	0·19±·013

Subsequently these results were corroborated by those of field tests carried on in several counties. At the same time the greater strength of straw and earlier-ripening habit of the hybrid was definitely established. In the malting tests Spratt-Archer proved superior to Archer, as the nitrogen figures would lead one to suspect, and thus Archer loses its position of superiority in the same way and for the same reasons that Chevallier did.

The effect of the slightly earlier ripening habit was reflected in the qualitative and quantitative result in the following way. In late-ripening seasons Spratt-Archer was unquestionably superior to Archer in yield and quality, whilst in early-ripening seasons, such as 1921, ripening was greatly accentuated, and the difference between the hybrid and the naturally later Archer, although in the same direction, was not so marked. But it will be remembered that 1921 was an abnormally dry, hot year, and represents a condition not repeated very frequently.

A word as to the economic effect of the introduction of Plumage-Archer and Spratt-Archer, which, for purposes of comparison, we may regard as identical in yield. Turning to the Irish yield figures we find that the substitution of pure-line Archer for Chevallier, as grown in the country in, say, 1900, may be claimed to account for an improvement of yield amounting to 7 bushels per acre, and that of Spratt-Archer for pure Archer, 4 bushels per acre, or a total improvement of 11 bushels per statute acre. Again, as both Plumage-Archer and Spratt-Archer are superior to Archer in malting quality, we may safely and fairly assume that the maltster and brewer have benefited in this direction.

Viewing Plumage-Archer and Spratt-Archer as hybrid varieties it is noteworthy that both exhibit high yield, combined with high malting quality. Exactly which attributes of yield are accentuated in these

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varieties it is not easy to say, but that they represent a closer approximation of the requirements of the two large interests involved than obtained twenty years ago is unquestionable. Plant-breeding is essentially the progressive accumulation of small improvements, and from that point of view the new barleys offer a jumping-off point for further effort along the same lines as I have endeavoured to indicate. The variety tests carried out by the National Institute of Agricultural Botany, in collaboration with the Institute of Brewing, during the two years 1925-1927, included Plumage-Archer, Spratt-Archer and Archer, together with three barleys appearing under numbers, and Sunrise—which is a selected Archer put on the market by Messrs Webb & Sons.

The numbered varieties No. 824 and No. 825 are narrow-eared selections from a cross between Russian Goldthorpe and Archer, made by Mr Engledow, at Cambridge, whilst No. 25 is a selection out of Plumage-Archer.

A brief survey of the results obtained during the period is appropriate here, for it brings what I have previously said up to date, and probably with greater appeal, as the tests were carried out in this country.

The figures of average yield for the three-year period show that Spratt-Archer is the most prolific variety, and this result is common to all the experimental stations. Archer-Sunrise, No. 25, and Archer-Goldthorpe were inferior to the standard Plumage-Archer. The two barleys Nos. 824 and 825 were included in two of the three years only, and it is difficult, consequently, to say exactly where they stand, but, taking the figures for the two years in which they were tested, they are superior to the standard by approximately the same amount as Spratt-Archer.

Combining the figures of yield and those of value derived from valuations and analyses made by the Institute of Brewing Valuation Committee, Plumage-Archer shows the highest value per acre. It is followed in order of merit by Spratt-Archer, and then by Nos. 824 and 825, No. 25, Archer-Goldthorpe and Sunrise.

Thus the final position is very similar to that I described above. As between the best barleys there is really very little to choose. There are indications of the partiality of some varieties for certain soils, and probably the operation of this condition accounts for many individual differences. By following up this aspect of variety work it may be possible to render the barley industry further assistance.

Whilst the determination of the relative values of varieties is a fundamental step in all attempts at crop improvement, it is by no means the whole story, and to translate this story into actual practice is not quite so simple as it appears.

Something between 60 and 70 per cent. of the seed used in this country is grown by the farmer himself or sold from farmer to farmer, and yet there are no steps taken to ensure either its purity or its trueness

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of name ; nor, so far as I am aware, have any effective steps been taken to organize an efficient seed-supply on a sufficiently large scale to influence the character of the crop by areas. I therefore submit this side of barley growing for the special consideration of maltsters and brewers. The regulation of a proper seed-supply has been the corollary of variety investigations in other countries, and it is no less necessary here than elsewhere.

INFLUENCE OF SEASON ON QUALITY AND YIELD OF BARLEY

By JAMES STEWART

In approaching this subject, I intend to take as my basis the conditions appertaining to the principal malting barley-growing counties as a whole. Therefore my findings can be taken to apply to the average results obtained in any one season.

Yield.—So many factors influence the yield that one cannot altogether go on the published statistics. It is quite evident that, given droughty conditions, the yield must suffer, and if the reverse be the case the yield is greater. In the latter case the yield suffers materially if the weather conditions are abnormally wet and cold ; for example, in the English barley crop of 1927, when weather conditions were without parallel since 1879, the average yield was 16·4 cwt., or 2 cwt. per acre *more* than the average of the last ten years.

Scotland, however, experienced normal conditions up to the beginning of August, but in August and September the rainfall was 14·93 inches against 5 inches normal, and this materially affected the yield, as the following figures show :

The average bushel weight of malting barley in Scotland in 1927 was only 51¾ lb. In 1925, which was a good summer, the average weight was 55 lb.

From a study of the yields in England and Scotland since 1920 the facts emerge :

(1) The yield is greater in a wet season.
(2) It is practically an average in a normal season.
(3) It is much less in a dry season, and also in an abnormally wet season.

The yields in Scotland are invariably greater than they are in England, and it will be generally acknowledged that there is more rain, less sun, and lower temperature in Scotland than in England ; but of course it must also be remembered that Scotch barleys invariably contain a much larger percentage of moisture.

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My experience has been that, given a certain amount of moisture, sunshine is not essential until the ripening period commences, and I take as an illustration the year 1926, which, according to the statisticians' reports, was a "Sunless Year."

SUMMARY SHOWING WEATHER CONDITIONS DURING AUGUST AND SEPTEMBER 1926 IN THE PRINCIPAL BARLEY-GROWING COUNTRIES

	Rainfall		*Sunshine*		*Temperature degrees F. Max.–Min.*
	Inches	*Normal*	*Hours*	*Normal*	
Norfolk—					
August	2·54	2·37	205	156	79–44
September	1·14	2·14	144	156	86–38
Suffolk—					
August	1·03	1·70	219	220	80–46
September	0·75	1·81	157	184	81–41
Essex—					
August	0·76	1·69	226	207	82–45
September	0·35	1·59	154	157	85–37
Lincolnshire—					
August	2·04	2·26	217	193	75–47
September	0·60	1·55	133	156	84–38
Cambridgeshire—					
August	1·10	2·35	194	187	79–42
September	2·44	1·61	148	151	86–35
Kent—					
August	1·07	2·33	204	200	78–44
September	0·51	2·25	140	152	84–35
Somerset—					
August	3·02	3·25	184	194	76–48
September	1·73	2·20	102	152	79–36
Scotland—					
August	1·85	2·94	178	148	73–46
September	3·80	1·76	133	121	79–36

During the growing period the crops were very prolific, but it is the weather conditions prevailing during harvest that I particularly wish to draw your attention to. It will be noticed that in nearly all the counties August has rainfall under the normal, with sunshine over the normal, whereas in September the outstanding feature is the low

https://doi.org/10.23637/ERADOC-1-200

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rainfall, sunshine under the normal, and a higher maximum temperature than that which prevailed during August. There is a record of seven severe thunderstorms.

The barley produced in August could be described as a vintage crop, but the warm, thundery and sunless conditions prevailing during the month of September severely damaged what remained in the fields, and was responsible for producing a barley quite different in character from that harvested in August.

Take, again, 1927, which was quite a sunless year. The accompanying Table (of 1927) will demonstrate that from the beginning of the ripening period until harvest there was abnormal rainfall, with sunshine much below the average, and is perhaps the best illustration that can be given of the conditions prevailing during that critical period. Notwithstanding this, the yield was 16·4 cwt. compared with 16 cwt. of the previous year, but a small correction should be made for the extra moisture which the barley contained.

SUMMARY SHOWING WEATHER CONDITIONS DURING JUNE, JULY, AUGUST, SEPTEMBER OF 1927 IN THE PRINCIPAL BARLEY-GROWING COUNTIES

County	*Rainfall*		*Sunshine*		*Temperature*	
	Actual Inches	*Normal Inches*	*Actual Hours*	*Normal Hours*	*Mean*	*Normal Mean*
Norfolk . .	12·56	8·22	590	758	58·8	58·8
Suffolk . .	12·79	7·89	699	871	59·3	59·7
Essex . .	14·57	7·00	669	825	59·3	59·3
Lincolnshire .	11·16	8·25	631	771	58·3	59·0
Cambridgeshire .	10·22	8·23	602	741	58·6	59·6
Kent . .	13·96	7·63	730	749	59·7	60·3
Somerset . .	17·58	9·63	578	757	59·0	59·3
Yorkshire . .	15·27	8·74	550	620	57·4	58·4
Average . .	13·51	8·19	631	761·5	58·8	59·3
Scotland . .	20·78	9·58	620	620	56·3	55·2

Many factors go to upset the yield—a poor seed-bed; late frosts; drought; abnormal rain or sunshine; or a wrong distribution of each.

But, apart from seasonal influences, the variety of barley sown in

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recent years has an important bearing on the yield ; the yield per acre has increased appreciably, owing to the use of the comparatively new varieties of barley—Plumage-Archer, etc.

The influence of season on quality is quite another matter, and has a more far-reaching effect ; take the year 1921, when, with the universal drought, the crops showed a decrease of 1½ bushels to the acre. The barley was prematurely ripened, and it had not completed its natural development. It had a nitrogen-content ranging from 1·7 per cent. and moisture 13 per cent., instead of the usual 16 per cent.

An examination of the ear showed that, in many cases, the basal bristle was not attached to the barley corn, but remained in the ear, with the result that the skins were not sealed together, as in a ripe corn. The base of the corn being thus open, the germ, from want of its natural protection, loses a great deal of its vitality, and on the malting floors rapidly develops mould. A further very bad feature is that, if used for malting purposes, it is quite impossible to get a proper modification, and the resultant malt is not only deficient in extract, and high in diastase, but creates many difficulties during the fermentation process in the brewery.

If, on the other hand, we consider a barley which has been through a very wet season, we cannot take a better illustration than the year 1927 —the wettest season we have had for about fifty years ; and when one considers that there is a range of prices from 38s. to 80s. per quarter, it will give some idea as to the very great variation which exists. All barleys are more or less weathered, and a large proportion fit only for feeding cattle. Owing to exposure they contain a large percentage of slack or loose-skinned corns. They also produced barleys which were unripe and those which were overripe (rather "washed," as I prefer to call them). The nitrogen-content ranged from 1 to 2 per cent. Barleys which were harvested in Lincolnshire and Norfolk—which counties largely escaped the rain in *August*—have showed excellent quality, and the later threshings are such that it is difficult to imagine they were grown in 1927. These barleys have a nitrogen-content of about 1·4 for the "Chevallier" varieties, and 1·6 for the "Goldthorpe" varieties.

Some of the "washed" barleys which have suffered most have a nitrogen-content of only 1 per cent. Their vitality is very weak, and they are all more or less sour. One has only to smell an English barley growing on the malting floors and compare this with a sample of a two-rowed, sun-dried "Chevallier" foreign barley at the same stage of growth to realize the effect of weather.

It might be interesting at this point to give you the following details in connexion with the barley which won the World's Champion Prize in 1926 :

The soil is stony brash gravel ; manure, "Fison's Fertiliser" ; seed, "Beaven's Plumage-Archer."

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	1926	1927
Seed-Bed :	Good.	Good.
Ripening Period :	Drought at beginning of ripening period.	The plant suffered very much during the drought in April and May; recovered with the rain in June, and later suffered from lack of sunshine.
Harvesting Period :	A combination of gentle rain and sunshine improved the quality, and the barley harvested exceedingly well.	Harvested during a favourable period.
Yield :	38 bushels per acre.	8 sacks per acre (32 bushels per acre ?)

This gives a striking example of the influence of season on the yield and quality of barley grown in a particularly favoured district.

The best of the barleys this year have produced analytically quite as good malts as last year. In some of them the soluble nitrogen is somewhat low, indicating deficient yeast-feeding properties, and thus causing fermentation troubles, and there are many brewers who are not prepared to take the risk, with the result that a very much larger quantity of sun-dried Czecho-Slovakian two-rowed barley has been imported into this country, which has meant thousands of pounds going abroad.

It is quite apparent that the growing of barley generally cannot altogether be regarded as a paying proposition, otherwise there would not be the continued decrease in acreage which has taken place since the War. The total decreased acreage since 1920 is, approximately, 760,000 acres, representing 2,850,000 quarters of barley.

Sugar-beet, on the other hand, has increased from 3000 acres, sown in 1920, to 221,700, sown in 1927.

Whatever grievance may exist among the agricultural community there can be no doubt that their greatest enemy is the British climate, and if we were favoured with the right type of weather the influence of the season, both on yield and quality, would be such that the result would be rapidly reflected in the farmers' pockets.

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CULTIVATION AND TREATMENT OF BARLEY GROWN FOR MALTING IN THE VALE OF TAUNTON

By JOHN JOYCE, Esq.
Taunton

Kinds of Seeds sown

In the Taunton Vale and West Somerset many various types of barley have been tried during the last thirty or forty years, yet very few really reliable facts and figures are forthcoming as to the results of yield, quality and price. It *is* a fact that growers have now *generally* relinquished the old Chevallier types, as well as the old Goldthorpe and some of its earlier varieties, for Plumage-Archer and Spratt-Archer sorts, and very few, I think, will carry on next season with any of the other crosses of the Goldthorpe kind.

The old Chevallier variety gave way to the Archer-Chevallier, and that again gave way to the Spratt-Archer, whilst the old Goldthorpe gave way to the newer crosses of that type, and finally to the Plumage-Archer.

Of the grain from these two types of ears—namely, Chevallier and Goldthorpe—the former being more open in the chest or ear is therefore more exposed to the weather, and we consider that bad weather affects the quality and colour of this open-eared grain more quickly than that in the closer-packed grain of the other kind. This is more noticeable in a bad season. In a dry season it is held that the Chevallier type of ear yields rather better quality, and with a thinner skin on the grain, whilst that from the Goldthorpe kind of ear is generally considered to be thicker in the skin and not so curly, hence not so much preferred by brewers.

Cultivation

The Taunton Vale varies as to the texture of the soil, and it is only on the red sandstone districts or lighter kinds of soil in the vales that one can really depend on producing barley fit for malting, continuously and consistently, year after year.

In the heavier classes of soils a good malting sample is produced only in a genial season. In the sandier and lighter lands barley suitable for malting can be relied upon generally up to a height of nearly 500 ft. above sea-level, but not higher.

Malting barley is grown after three kinds of previous crops—namely :

First.—After young grass, clover, or mixed seeds produced the previous season, which we call " ley " land. These leys are ploughed

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down in the late autumn or early in the new year. The furrows are often pressed down with a roller and two or three horses, which consolidates the earth and prevents loose pockets occurring between the earth that is moved by the plough and the solid earth that lies underneath it. The next process is to go over the land with a spring tooth-drag or harrow, about three times, each time crossing the furrows a little and also crossing the previous operation, so that the soil gets thoroughly mixed up together, and thoroughly loosened at a good and even depth. We then harrow, not so deeply, about twice, making about six operations in the whole before drilling.

This, generally speaking, after ley, should make a good tilth, or seed-bed. The constant passing over it with the horses during the operation should make the bottom, especially the last two harrowings, of an even character and fairly firm, while the top portion, to about three or four inches, should be loose and fine at that depth.

We find two bushels per acre sufficient with the Spratt-Archer variety, and just a little over that amount on the ley ground with Plumage-Archer—perhaps half-a-peck more per acre—for the Plumage-Archer does not tiller quite as much as the Spratt-Archer or New Cross. Some drill more seed than this, even up to two and a half bushels per acre, but where the land is in good heart and condition, and the cultivations before drilling are efficient and ample, I maintain two bushels are enough. A harrow in after the drill completes the operation.

Second.—Land for barley after a previous straw crop—for we often put barley after barley since wheat has been lower in price than malting barley. This errish land would generally have been skim-ploughed about three inches deep in the previous autumn, and worked out fine, and, like the ley, not ploughed down till late December or early January. This would not need a roll on the furrow in ordinary times, but scratching the furrows with harrows, once or twice over, then a spring tooth-drag to get down fairly deep again, about three times over—each time more or less crossing the furrows and also crossing the previous working—then about two harrowings on top again, and drill and harrow in as described for ley ground.

Third.—Barley after root crops, which are generally folded with sheep the same winter as the barley is drilled in in the spring. It is very important in this case that this land, after the folding with sheep, should be ploughed when nice and dry and not ploughed down muddy and wet, or otherwise it will dry in lumps and will never break up nicely. After folding with sheep, some farmers in this neighbourhood do not plough more than about four inches deep, but if the land had a catch crop on it the previous year before the roots were planted—that is, trifolium or vetches were folded down the previous spring or summer, and that folding ploughed down fairly deeply for the roots—then the ploughing for barley after the roots the following spring should, I think, also be at a good depth—namely, six or seven inches—bringing up on top

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again the previous spring foldings and manurings of the previous catch crops. After ploughing, and whilst the first two workings should be with the spring tooth-harrow, and should be fairly deep, the remaining workings, if it breaks well, should consist of two harrowings and a roll down before drilling, and drill on the rolling. Of course, if the weather should set in pronouncedly dry, and small lumps are formed, it might have to be rolled once or twice more, and more harrowings given between the rollings.

This, in a general way, constitutes the three classes of land for barley, and how it is generally treated in this neighbourhood.

My description of barley after roots means also land where sugar-beet, mangels or potatoes and cabbage or kale have been grown, only in these cases the land may not have been folded with sheep. We do not generally, in this neighbourhood, plough twice after any of these crops for barley. I have heard of twice ploughing for barley recommended on land farther up the country, and I have tried it in Somerset. The other day I put the question to an old barley grower—one of the best growers we ever had in the West of England, Mr J. B. Corner, who won several prizes for the quality of his grain, and who used to grow also, at the same time, heavy crops—and he told me his experience had been the same. He said, rather than plough twice he would lightly run the cultivator over it after the root crop had been folded, and with harrows and chain-harrows rub it out fine, and then plough down only once. You will remember I recommended, after errish, that the land be thinly skimmed and rubbed out finely and then ploughed down, but not what is known as second or "cross-ploughing."

The barley is now in the land ready to grow, but care must be taken to keep off rooks and pigeons, which often do considerable damage by scratching the soil and picking up and eating the sown grain, especially when it has sprouted out and the young sprouts are just breaking through the top crust of the earth. These birds then scratch and easily find the sprout that is just coming up, and they know that at the bottom of it there is a grain all malted and sweet. Just at this stage of growth another harrowing, right across the opposite way to which it has been drilled, often answers well for many reasons; one is, that if there has been heavy rain, and the top soil has scaled, the harrows break this scale and re-loosen the soil around the sprouting barley. Another reason is that it kills many small weeds which have already sprouted out. There should be no rolling until the blades are thoroughly strong, deeply rooted, and on the verge of tillering or branching out, for the blade makes greater headway when the earth is fine and loose about it than when pressed down tightly on it. Then, in about four or five weeks after it has been sown, a roller can be used to press down any stones which may be on top, and to level the land for the binder at harvesting; but I have never found that it helps the barley to grow—in fact, a few good barley growers continue to drill eight inches apart,

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from colter to colter, and they run the horse-hoe through the spaces between the drills, instead of rolling, when the barley is about this stage. I personally do not do this, but follow the more usual method.

All thistles and weeds must be hoed out, and in order to do this thoroughly the barley should be gone over the second time to catch the smaller thistles which were missed the first time.

Manuring

We do not find that barley in Somerset visibly responds to any artificial manures, except the nitrogenous ones—such as nitrate of soda or sulphate of ammonia—and for that portion of barley which is sown after a previous corn crop it generally pays to put 1 cwt. per acre of either of these fertilizers, and if sulphate of ammonia is chosen it may be applied broadcast just before harrowing across the last time, and if nitrate of soda a little later on.

The root lands, if they have been folded with sheep, should not require any artificials whatever, even on poor light soil ; neither does the ley barley if the land is in good heart or if the previous ley seeds have contained a good proportion of clover. But if there were few clovers in those seeds, no matter from what cause, and the ley consisted chiefly of rye-grasses mown for hay, then 1 cwt. of nitrate of soda or sulphate of ammonia would be required there to produce a good crop quite as much as it is required on barley which was sown as a second corn crop.

Of course the best stimulant for the growth of all malting barley on all soils would be a tax on the foreign barleys entering our country and used for malting.

Harvesting

To obtain a good sample of malting barley it is essential and important that the grain in each ear of barley is thoroughly ripe before it is cut. On some land the ears of grain ripen off together much better than on other kinds of land ; but the only method I know of which the grower can employ in order to produce an even sample of grain is to refrain from cutting his barley until all the backward ears have got thoroughly ripe, although this may entail the risk that some of the forward ears which were ripe earliest may turn their heads down, even touching the ground, and be cut off there by the binder, and so many of those heads may not be gathered in the sheaf at all. This is unfortunate and vexing to see, when many heads of grain are so wasted on the ground ; and it is a problem the grower has to decide for himself, either to cut, or to wait, and which is likely to be more profitable—cutting early and securing all the grain, but having at the finish a poor, uneven sample, or waiting longer before cutting, ensuring an even sample, but losing many of the heads on the ground. There is certainly an art in producing and delivering a first-class malting barley crop year after year.

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Buyers of malting barley, who are generally good judges, like every grain of the sample presented to them to have been dead-ripe when cut, and they are able to distinguish a sample that is such almost at a glance. The reason for such importance being attached to this is that, in the process of malting, when the grain is damped and required to grow out, it is most desirable that all the grains should germinate and grow out together, and this occurs only when all the grains are of an even ripeness, whereas in an unevenly ripe sample the grains grow out or sprout at irregular times.

Cutting

We cut with a binder, and this, of course, must be done only when the straw is dry. We stook up after with about eight sheaves to a stook, and these stand a few days to allow any weed or greenstuff in them to dry off. If bad weather arrives, and these stooks get wet, and the sheaves get wet in the middle, the stooks must be reset and dried, even if it entails handling and cutting the cords around some of the wet sheaves, for if the barley is carried with even a small percentage of sheaves damp in their middles, though it may not be enough to make it heat much in the stack, the barley, when threshed, will smell stale and old, and not look fresh or smell sweet.

Ricks

Barley is now often carted into dutch barns and threshed therefrom, but, if put into stacks, the stacks must be thatched up quickly or else the tops of the ricks will get damp and the barley will grow out, and barley that has sprouted, either in the stack or in the field, is no good for malting.

Threshing

In threshing great care must be taken to set that part of the machine which cuts off the "iles" or beard from the grain, just right for each lot of barley, for if these iles attached to the grain are cut off too short the skin on the end of the grain is liable to be stripped off along with it—at least from some of the grains—which prevents or checks the growth of that grain ; and if, on the other hand, the iler is set to cut the iles too long, the sample will not look so plump and full ; but it is better for malting to have these ends of the grain a little too long than too short.

After Threshing Management

There are two methods of treatment in vogue in West Somerset—first, sacking and weighing the barley off as it comes from the thresher and sending it to the buyer in that state and condition ; but in this case the buyer should be told beforehand that this is the plan adopted ; or, secondly, to shoot the grain from the thresher into a heap on the floor

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of a barn or granary, and when delivering to the buyer to mix it and put it through the winnowing machine, and then sack and weigh it up from the winnower.

The best method I know of taking the sample to sell by, in either case, is to have an extra sack by the side of the threshing machine and to place a handful of barley in it out of every sack as it is filling. If the first method of delivery is adopted, and when this sample sack is shot and mixed, this will be the sample to sell by ; but every sack of this lot will not be like the sample, nor, necessarily, exactly like the other sacks of the same lot. Hence the necessity of the buyer knowing that this is the method adopted, and he should know what to expect. But if the second method of delivery is followed, of shooting it in a heap, mixing and winnowing, and sacking it up and then delivering it, then the sample sack can be shot out, mixed and nicely winnowed, as the bulk will be later, and in this way one is able to present to the buyer every sack of grain like the sample by which it was sold ; and hence all the sacks, too, will be like each other sack, whereas, by sacking and delivering it direct from the machine, however careful one is in threshing, one cannot depend on having the barley in each sack alike.

In the Somerset National Farmers' Union we get many cases of dispute brought to us every year arising out of this method. I may say that we in Somerset, together with the corresponding County Branch of the Corn Merchants' Association, generally manage to settle these disputes by our good offices, or by arbitration, and without resorting to the law, but, generally, at more or less loss to the grower.

CULTIVATION AND TREATMENT OF BARLEY GROWN FOR MALTING ON LINCOLN HEATH

By G. H. NEVILE
Wellingore

The "Heath," in Lincolnshire, is the local name for the tract of land whose western edge is the oolitic limestone escarpment running between Grantham and Lincoln. The escarpment itself rises about two hundred feet above sea-level, and drops sharply to the vale of the Witham and Brant on the Lias clay formation. The villages are all on the edge of the escarpment, and the parishes are long narrow parallel strips, partly on the Heath and partly on what is locally termed the "lowfield." Farms are large, and, like the parishes, usually contain a proportion of Heath and a proportion of lowfield land. The Heath itself is almost

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entirely under the plough, an occasional field of permanent grass being found alongside the farmsteads. Near the villages the land is of good medium quality, with 6 to 10 in. of soil above the oolite Brash, but as we proceed eastwards the land gets lighter and thinner, and there is not more than 4 in. of soil. Probably two-thirds of the Heath is on this light dry 4 in. of soil, and it is on this that the best-quality barleys are produced.

This is essentially a sheep and barley district, and the farming system is the four-course one where barley is followed by seed, wheat and roots. Occasionally, on what I will call the 7 in. land, a second crop of barley is taken and, normally, barley replaces part of what should be the wheat area. Since the War, potatoes have been grown in places, as, although crops are light, the Limestone Edwards always command a sale at prices above those of the fen and silt lands. Lately sugar-beet has been introduced, and has here displaced roots and, consequently, some sheep, but the soil is too shallow and dry to anticipate a crop of more than 8 tons to the acre on the 7 in. soil and 6 tons on the 4 in. quality. With the reduction in the price now coming into force it looks as if this area is among those which will have to relinquish the growing of this crop.

With all the Heath devoted to arable crops it will be noted that there is no pasture for the cattle required to tread the straw into manure in the yards in winter. It is for this reason that, where possible, farms have a proportionate area, say one-third, on the lowfield, and this is largely second-class pasture-land, the remainder being devoted to wheat and oats, with one-fifth or one-sixth as summer fallow.

Farms here can be stocked for about £10 or less per acre, and are run on the most economical lines. Rent varies from 30s. per acre on the good land to 12s. on the poor.

The limiting factor in crop production in this area is undoubtedly drought. The mean average rainfall is 24 in., and this amount would prove ample for a maximum crop production provided it was evenly distributed. Unfortunately, in every year we may anticipate a period of at least four weeks practically without rain, and on these shallow soils this annual drought is the determining factor in the yield of our spring-sown crops. To take two examples. In 1927, between 15th April and 15th June we had less than 1 in. of rain, or one-quarter of the mean. Since then it seems to have rained continuously. The interesting point to me was that the heavy rainfall from 15th June onwards was in time to secure maximum crops of barley. These were fully 20 to 25 per cent. above the average in quantity. The 4 in. land produced 5 quarters per acre instead of 4 quarters, and on over 80 acres of my best land I had 7 quarters per acre, while some of my neighbours had yields of 8 quarters in individual fields. The later rainfalls, of course, spoiled the quality, and there were very few first-class samples.

In 1925, after good rains in May, only 1 in. of rain fell between

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27th May and 5th August, by which time the barley was ripe. Although in yield the crops were only average the quality was excellent, and good prices were realized. In trying to understand the factors governing crop production I have been struck by the small average size of the head. The Spratt-Archer barley which I grow has normally 18 buds per side in its early stages, but of these I find that at harvest only the 12 lower seeds per side have matured. I had imagined that after the drought in May and early June in 1927 the damage had already been done, and was agreeably surprised to find that the rain subsequent to 15th June was still early enough to produce heads much above the average. It is apparent that if the normal head has only 12 seeds a-side, and we can increase that to 15 or 16, the yield must be increased very largely, and, as fresh tillering after 15th June is improbable, the large crops this year may be attributed to this cause.

On our farms, for barley, sugar-beet and potatoes the most important time for rainfall is May and early June, and it has often struck me that an insurance company that would ensure us 1 in. of rain in each half of May and in the first half of June should do good business. It would seem that only a small premium would be necessary, as our need of rain would set off the fine-weather requirements of pleasure-seekers who take out "pluvius" policies for cricket matches, shows and the like.

To return to the cultivation of our Heath farms. Starting with the clover seed in the rotation, about two-thirds of the seed area would be grazing seeds, where 5 lb. of white clover, 5 lb. of alsike and 7 lb. of Italian rye-grass would be a usual seed-mixture. Although perennial rye-grass stands a summer drought better, the Italian is preferred as essential for the first early bite for lambs. Half the rye-grass is frequently sown mixed with the barley in the drill when the latter is sown, and this rarely fails from drought. The remainder of the rye-grass and the clovers are sown with a small seed-drill across the barley drills in April. These grazing seeds should carry two ewes and pairs throughout the summer on the good land, though 5 mouths are sufficient on the light land. The ewes and singles run chiefly on the lowfield grass-land, which should carry a ewe, a lamb, and half a beast per acre. The remaining one-third of the seed area is sown to a mowing mixture of red clover and Italian rye-grass, and this feeds the horses and cattle in winter. The weaned lambs run on the aftermath before it is ploughed for wheat. Generally half the grazing-seed area is reserved for barley instead of being sown to wheat, and this swarth-land barley is reputed the better, both in quantity and quality.

On the better land, where, if clean, an extra barley crop may be taken, roots follow the wheat, and large areas of swedes and turnips are grown, as the sheep are carried well into the spring. Possibly 20 per cent. of the root area is taken for beet or mustard seed. An acre of swedes should carry 8 sheep for the 20 weeks of winter on the better land, but 100 sheep-weeks is all that is expected of the 4 in. land. It may

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be well to note here that where sheep are fed on sugar-beet tops they should run on these only in the daytime, and go on to seeds at night, to give them time to cleanse their mouths and stomachs of grit, which otherwise may cause serious losses.

On a typical four-course farm, such as I have in mind, a ewe flock of 30 large Lincoln ewes per 100 acres would be carried, and sales would average 34 to 35 head per 100 acres. Where the sheep are largely sold as clipped hogs the wool clip is expected to pay the Lady Day half-year's rent. The sheep, while on roots, would receive on the average half-a-pound of cake or meal per day, so that 4 or 5 cwt. of cake or corn is eaten on each acre, and this, with a little phosphatic manure applied to the roots, is, in many cases, the only extraneous help the land receives, and it is surprising the high state of fertility that is maintained by this system. Of horned stock some 4 or 5 cows, with their progeny—say, 18 head in all—is carried per 100 acres.

The cows calve in the spring and rear a calf apiece on the grass-land in the lowfield in the summer, and in winter they go into yards, where they live on barley straw, roots and a foddering of clover hay. In some cases they may get 2 to 3 lb. of cake a day. Sales per 100 acres would be 4 to 5 head, sold as stores and drape cows. As on the lighter land it is necessary to work as much of the twitch out as possible before the roots, much of the manure made in the yards goes on to the clover-land before it is ploughed for wheat.

After harvest, when the root-break has been ploughed, the swath-lands for barley are tackled, generally before Christmas, and the root-break follows as the sheep clear it. In a favourable February the drill is got to work as soon after 10th February as possible on the 4 in. soils, and it is recognized that the earlier sowings give the best qualities. On the 7 in. land the middle of March is probably as good a time as any, though here, again, February sowings have an advantage if there is an early spring drought. Swath-land may receive five harrowings—three down the furrows and two across—and one or two cultivations and two or three harrowings are usual on the root-land. Disc drills are largely employed, and a full seeding of 11 or 12 pecks is favoured. Lighter seedings are considered to encourage tillering, which is looked on with disfavour as promoting second growth. Myself, I consider this a fallacy and operative only where the seed has been sown too deep. I find that with the average crop there are only three heads to two roots. I myself advocate shallow sowing, and, under favourable conditions, this results in a large number of tillers at a very early stage of growth. A deep-sown seed throws up a long, spiky plant, which does not multiply until a fresh crown root system has formed near the surface, and then the primary seedling root dies off. The secondary shoots so formed are necessarily much later than the first, and may well result in small heads of unripe corn at harvest.

Where shallow sowing is adopted, rapid root development takes place,

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and half-a-dozen shoots are soon developed, all within a few days of one another; if the plant is a thin one all of these may develop good heads. With a fair plant, however, it is rare for more than, say, three out of six shoots to come to maturity, but these should all be good heads. Other limiting factors—drought, a cold spell or insufficient food-supply—have brought their influence to bear, and the plant has restricted itself to what it can bring to maturity. The disadvantages of surface-sowing are the depredations of birds—particularly the finches—the possibility of frost injuring the plant before it is established, and the risk that the surface soil may dry out before the roots have got down if it is a rainless season.

I hold the opinion that, with shallow-sown crops, the straw is stronger; there is a minimum of laid corn, a thin plant fills out well owing to its tillering capacity, and, where the plant is a good one, a large increase in the plant population is possible. Necessarily, in any individual case the adverse factors must be balanced against the advantages, and it is perhaps fairest to put the case no higher than to say that sowing too deep is a limiting factor.

As already mentioned, little artificial manure is used on the greater number of Heath farms.

A phosphatic manure is applied to the roots, and some of the more successful farmers now use a dressing of kainit for their barleys, as they consider it brightens them. Years ago large quantities of salt, then at 17s. a ton, were used, and this practice is coming into favour again.

Two of my friends had an interesting experience this year. They had adjoining fields, both swath-land, similarly cultivated, sown with Webbs' New Cross on the same day, and harvested at the same time. Both had good crops, but when it came to sale-time one sample fetched 70s. the quarter and the other 50s. The only difference in cultivation appeared to be that the better sample had had 4 to 5 cwt. of salt per acre as against a smaller amount of kainit. I think Rothamsted recognizes that chlorides produce a bright barley, but this difference in value is rather striking. There may have been other factors. Salt is also considered to strengthen the straw.

Personally, I like to employ a complete manure, consisting of 1 cwt. sulphate ammonia, 1 cwt. potash salts or 2 cwt. kainit, and 2 cwt. slag or North African phosphate—or other cheap raw phosphate. Manurial trials carried out under Rothamsted supervision have shown little benefit from superphosphate on this land. On two occasions, however, on land not in good heart, where slag had been distributed by an old rotary distributor which was working badly, I found the fields in regular waves of high and low barley, which coincided with nothing but the faulty slag distribution. As the nitrogenous manures had been sown by hand across the waves I formed the opinion that the nitrogenous manures had given their best effect only on the well-slagged portion, and there was certainly a very marked difference in the crop.

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As regards quality, I have employed artificial nitrogenous manures freely and have found no ill effects.

On the other hand, I think too-liberal manuring with organic manures is liable to result in a coarse-skinned, nitrogenous, dull sample of barley, which in a wet season is associated with a long, weak straw, liable to go down—at all events on the 7 in. land. As with us the wet years do not predominate, the crops following roots and sheep do not suffer much on the lighter land.

The favourite types of barley for our Heath-land are at present undoubtedly Spratt-Archer and Webbs' New Cross. Of the two, I think the Spratt-Archer has proved the favourite with the brewers this year, and I think myself that it is the better yielder. I have given a good trial to Beaven's 1924 and Plumage-Archer and have never had a really good sample on this land. These barleys undoubtedly require moister conditions of soil or climate.

A local practice is to grow our barleys for malting on the Heath, and on the lowfield for seed. One season on the cold, damp clays seems to rejuvenate the barley, which undoubtedly degenerates if grown on the Heath for too many years in succession.

On the lowfield it takes on a thicker coat and develops a larger and more nitrogenous seed, with a strong germ, which, in appearance, would not naturally attract buyers looking for a good malting type to sow.

1925 was a dry year, when June and July were, with us, practically rainless. In that year I sowed a 10 acre field, after sugar-beet, half with Spratt-Archer—which had been grown on the Heath for several years—and half with Beaven's 1924. This latter was a beautifully even piece, every plant the same length of straw and ear, with every appearance of pedigree and breed. The Spratt-Archer was most uneven, all humps and hollows, and apparently grown out.

When harvested, the Beaven's 1924 yielded 46 bushels, against 42 bushels for the Spratt-Archer, but the latter sold for 70s. per quarter against 55s. for the 1924.

The Beaven's had not finished well under the dry conditions. Crops grown subsequently from the same stock of Spratt-Archer after one year on the lowfield have proved quite satisfactory and given good yields this year.

It is generally accepted by Heath growers that the best barley crops for both quality and yield are those following grazing seed—the swath barleys. Barley, after a white straw crop, again gives good malting quality, and, where the season has been kind, winter-sown barley is possibly the best of all for quality, with a particularly small plump berry, but it has proved a light yielder. This winter-sowing is not a regular practice for the Heath, but I have experimented for several seasons, using Spratt-Archer, with varying results. On the first occasion, in 1925, on which I tried it on a large scale I was lucky, and had 5 quarters per acre, which sold at 90s.—the best barley I have

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grown. Next year 15 degrees of frost in mid-November caught the barley before the green leaves were through the sheath, and that was fatal.

In 1927 the barley passed the winter well, and looked very promising until May, but our drought was from 15th April to 15th June, just when it was ready to shoot, and the crop was consequently very light and the quality inferior. So far, this winter it has done very well. There is always a tendency to loss of plant in the winter-sown crop, chiefly, I think, caused by insect pests. Somewhat large claims are made for sugar-beet as a preparatory crop for barley. I have always had a satisfactory crop following beet, but I know of no definite rotational experiments where the beet and other crops were treated alike.

Where the beet has had a complete dressing of artificials, and the tops have been eaten off by sheep, this is likely to give a larger crop than where the preceding crop has been unmanured. Again, where the heavy crop of roots has been eaten off by sheep the yield may be greater than in a crop following beet, though the quality of the latter will be superior, due, as I think, to the heavier organic manuring in the former case.

This year I had in the same field 10 acres following potatoes—5 acres after beet, and 5 acres after mangolds. The preliminary crops had the same treatment—viz. 10 loads of dung per acre and similar dressings of artificials—the chief difference being that the potatoes had dung from the pig yards, whereas the roots had cattle manure. The potatoes were only a half crop, owing to blight, but the beet and roots did well—the beet, indeed, yielding about 11½ tons per acre. The differences were very marked in this year's barley crop. A month before harvest the barley following potatoes was 8 in. taller, greener, with a tendency to lodge, and eventually was quite a week or ten days later in ripening. This was apparent to a drill row. There was no apparent difference in the mangold and beet portions. These stood well and were altogether brighter than the potato barley. When I had threshed 7¼ quarters per acre from the roots area I anticipated, from the number of loads carried, that I should get over 8 quarters, if not 8½ quarters, per acre from the potato piece, but as a matter of fact it threshed out at just the same as the first plot, at 7¼ quarters. No doubt several bushels were lost owing to lodging and difficulty in harvesting, but there was nothing like the difference that the weight of straw had promised. It must be noted that this was a very wet year in July, August and September. Had we had a dry period in those months it is quite probable that the potato portion would not have been laid, but would have produced a heavier and better finished sample than the root portion. Pre-War farmers used to tell us that potatoes killed the Heath-land, but where artificials are used I do not think it is so. Possibly after a light winter rainfall it might be found that potatoes had unduly depleted the land of moisture.

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Before concluding, I should like to touch on the economics of these barley and sheep farms. It is claimed that the re-establishment of the gold standard has steadily reduced the cost of living to the general mass of the people. This is undoubtedly true, but if merit is claimed for the reduction in the cost of living to the consumer, the responsibility for the loss to the producers cannot be shirked. Nearly four years ago the agricultural index figure stood at about 70 per cent. above the pre-War basis—its peak in recent years—and since then it has steadily dropped till it reached 37 and 38 per cent. in the last months of 1927.

It is doubtful whether the general public recognize that this represents a loss of turnover of over £40,000,000 a year to the agricultural community, or about 20 per cent. of the earning power of our farms, omitting vegetables and fruit gardens. To come down from the general to the particular, I have examined the sales on a neighbour's farm and I find that over a number of years the average sales have been per 100 acres of total farm—grass and lowfield included—55 quarters of barley, 42 quarters of wheat, 4¼ beast, 35 sheep, and about £66 worth of various produce—pigs, poultry, potatoes, wool, etc. On the 1924 figures these were worth £625 for the 100 acres, and at present prices this amount would be reduced to £484—a loss of 28s. per acre, or just over 22 per cent. The particular farm on which these figures are taken has never yet shown a loss (no interest on capital being charged) and it is indicative of the great economy with which these farms are worked that last year, with sales down to £5, 8s. per acre, there was still a small margin of profit. It is doubtful whether that will be the case this year. Of this small total the plus value of malting as against feeding barley accounts for about 12s. per acre. Both malting barley and sheep have been relatively high in price compared with beef and wheat—the staple produce of the lowfield farms—and, taking 1 quarter of corn and 1 live cwt. of beef per acre as a high measure of the productivity of this class of land, it is seen that at the recent low-price levels the sales would not amount to much over £4 per acre.

Our malting barleys have to find a market in the face of a tax, in the form of the duty on beer, which amounts to £85 per acre. This has reduced the consumption of malt from 6,000,000 quarters in 1913 to 3,600,000 quarters in 1926. As 900,000 quarters of the latter were foreign barleys, only 2,700,000 quarters of our home-grown barleys are now required by brewers out of a crop which in a good year may amount to 4,000,000 quarters of malting quality.

In my opinion a reduction of the beer duty by the equivalent of 1d. per pint, making up the Budget deficit so caused by an all-round tax on imported meat, with a preference to Colonial produce, would benefit the whole of the rural community, and our barley-growers in particular. To ask the consumers to pay the higher price for home-grown meat would be only reclaiming a small part of the benefits the gold-standard policy has already conferred on them.

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FIVE YEARS' EXPERIMENTS ON THE GROWTH OF BARLEY FOR MALTING

By Sir JOHN RUSSELL, F.R.S.
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These experiments were made as part of an extensive investigation into malting barley fostered by the Institute of Brewing. From the outset the agricultural side of the investigation has been conducted from Rothamsted, and the purpose of this has been to ascertain the influence of soil, season and manuring on the yield and quality of the grain. The method of the experiment consisted in growing a particular strain of barley on a number of farms recognized as good barley-growing farms, using the same scheme of manuring at each, but leaving the farmer free to cultivate in whatever way might be the best. The variety chosen was Plumage Archer, selected because it is probably more commonly used at the present time for malting than any other variety, and further, because it has the advantages that its heads stand up and its straw is stiff and strong. Seed from the same threshing was used at all the centres so that the results might be strictly comparable. The experiment was continued for four years without change at any centre ; it is still continuing at a selected few.

Effect of Soil, Season and Manuring on Yield

Effect of Soil.—The effect of soil is very marked, both on yield and on quality. Probably the chief factor determining yield is the ease of drying out ; they are lowest on the light sandy soils in dry districts ; they are higher, and indeed may be very high, on sandy soils in moister conditions, or where evaporation is low ; they are intermediate on the heavy loams. On the very light dry soil at Martlesham, Suffolk, the yield has varied from 7½ to 16 bushels per acre, while on the moist sand of Dunbar it rose to 65 to 78 bushels. On the light loam overlying chalk or limestone the yields have been about 40 to 50 bushels, on the heavier loams they were less.

Effect of Season.—Barley being very sensitive to the soil tilth, it is much affected by the weather before the time of sowing. If the seed-bed is good the best seasons are those having ample rain in April, May and June, with dry sunny July and August. Up to the end of June the amount of sunshine seems to make little difference to the yield : England is apparently always sunny enough during spring and early summer for the not very exacting barley crop. Sunshine in July and

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August seems, however, to be more important. Spring drought, which is not uncommon in the Eastern Counties, where most of the barley of the country is grown, is unfavourable to yield on all soils, and may be very harmful on light sands ; on the loams, however, the crop may still recover if sufficient rain comes in time in June.

The years 1922, 1924 and 1926 were all good yielding years ; in all these the spring months were wet : 1923 and 1925 had dry springs, in both years some of the centres suffered.

Effect of Fertilizers.—1 cwt. sulphate of ammonia per acre increases the yield of barley almost every year, and at almost every centre, by about 3 cwt. (6 bushels) per acre, even when the crop followed roots fed to sheep or mangolds or sugar-beets receiving farmyard manure. The exceptions have been on the fen soils, the good Shropshire soils and, in 1922 only, the light Woburn soil, where the barley had been grown after a crop receiving farmyard manure.

Even better increases are obtained by muriate of ammonia in quantity supplying the same amount of nitrogen : some of the results are :

EFFECT OF MURIATE OF AMMONIA ON BARLEY : BUSHELS[1] PER ACRE

	Woburn 1926	*Rothamsted* 1926	*Longniddry* 1927
No Nitrogen	32·2	47·9	...
Muriate of Ammonia . .	47·1	47·7	63·6
Sulphate of Ammonia[2] . .	39·3	44·4	58·8
Advantage of Muriate over Sulphate	7·8	3·3	4·8

These increases given by ammonium salts are the most consistent of all the results.

The increased yield is due to an increase in the number of heads bearing grain, not in the number of grains per head.

Effect of Potassic and Phosphatic Fertilizers

When all the results are brought together, and averaged out, it does not appear that either superphosphate or sulphate of potash has had much effect on the yields. The figures are :

[1] Throughout this paper 1 bushel = 56 lb.
[2] 1 cwt. sulphate of ammonia = 90 lb. muriate of ammonia per acre.

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PERIOD 1922-1925

Decrease in Bushels per Acre 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 .	6·20	4·6	6·6	5·8
3 cwt. Superphosphate .	1·70	(1·1)	3·0	1·2
1½ cwt. Sulphate of Potash .	0·25	(0·1)	1·9	0·7

When, however, the figures are studied more closely, it is seen that both phosphate and potassic fertilizers have beneficial results in some seasons and on some soils, but both are very dependent on weather conditions. In each year superphosphate has increased yields at about half the centres, except in 1924, when it was less effective. At the Norfolk centres—all light loams—it has always acted beneficially, and this result is important, because Norfolk is the chief of the barley-growing counties of Great Britain. On the heavy soil of Rothamsted it acted in 1926, and still more in 1925, when a warm moist sunny May was followed by a June drought, but it was ineffective in 1922 and 1923, years of dry May and June, and also in 1924, when May was very wet: taking all the results into account, no single relation between weather and phosphate efficiency can be seen, nor is there any obvious connexion with soil type. The reason for the increased yield is an increase in the amount of tillering—an effect well seen on the Hoos field at Rothamsted. Another effect, clearly shown there, was not observed with any certainty. With the possible exceptions mentioned later, at none of the centres, not even those where the phosphate increased the yield, was there any sign of the marked hastening of ripening that is so striking a feature at Rothamsted.

The broad result is that only at the Norfolk centres would dressings of superphosphate have paid; elsewhere a profitable increase is obtained only in certain seasons. This does not mean that barley can do without phosphate; indeed the Rothamsted experiments show clearly that any attempt at phosphate starvation brings down the yield badly; this is shown by the following data, given in bushels per acre:

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Year	*Superphosphate given at time of Seeding*	*No Phosphate given since* 1904
1909 . .	40·60	36·60
1914 . .	37·32	23·27
1922 . .	37·80	20·25

There had been no superphosphate given for five years before the first barley crop was taken, and yet the yield suffered but little —only 4 bushels per acre. But the withholding of superphosphate for a second period of five years caused the serious drop of 14 bushels per acre, while further starvation brought the yield still lower.

In ordinary practice the most economical way of supplying the necessary phosphate to the barley is to give sufficient to the root crop, and, if necessary, to the seeds. Depressions in yield are recorded on the plots receiving superphosphate at Orwell in 1922 and 1924, Woburn in 1924, and Chiselborough in 1925 ; these are all light soils. The only explanation that can at present be offered is that the phosphate hastened ripening too much, and it was already rapid enough on these soils.

Potassic Fertilizer.—The effectiveness of sulphate of potash is almost entirely determined by weather conditions, there being no centre where it consistently increased the yield.[1] It was most effective in 1922, when a wet April was followed by a dry May and June, and a sunless July and August ; it then acted well at about half the centres, being as effective as nitrogen at Rothamsted, Cawkwell, Woburn and Dunbar. At Rothamsted the plants without the potash suffered during the spring drought, and by the end of June were beginning to look yellow. This beneficial effect of sulphate of potash during drought, but still more its great advantage in the sunless July and August, accord with what is known of the effect of potash on the plant. Potash increases the efficiency of the leaf as an assimilator of carbon dioxide : it thus helps to overcome the bad effect of lack of sunshine.

Another way of stating the same result is that sulphate of potash is most helpful in years when ripening is most delayed, while phosphate seemed more useful when it was less delayed. Setting out the crops in the order of their dates of cutting, which indicate approximately the order of ripening, the results are :

[1] There was no centre on the thin chalk soil, where potassic fertilizers generally act well.

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Year	Date of		Interval Days	Increased Yield given by	
	Sowing	Cutting		Sulphate of Potash	Super-phosphate
1922	Mar. 30	Sept. 12	167	+5·6	*nil*
1926	Mar. 16	Aug. 23	160	+1·7	+2·7
1925	Mar. 19	Aug. 18	152	*nil*	+4
1923	Apr. 18	Aug. 16	120	*nil*	*nil*
1924	Mar. 18	Aug. 15	150	−4·6	*nil*

If at the time of sowing the barley we could predict the date of cutting it would be possible to decide whether to give phosphates or potash in addition to the sulphate of ammonia. Neither the time of sowing, nor the number of days in the ground, shows so close a connexion with effectiveness of manure as does the time of ripening.

The sulphate of potash had no effect at most of the centres in 1923 and 1925, when April and May were dry and July was sunny. In 1924, however, a remarkable result was obtained, it *lowered* the yield. A wet May and June had succeeded a wet April, and July was very sunny. The effectiveness of the fertilizer is apparently independent of the hours of sunshine during April, May and June, but, as 1922 shows, it does depend on hours of sunshine during July and August. The results at Rothamsted are :

POTASSIC FERTILIZERS ON BARLEY AT ROTHAMSTED

Year	Effect on Yield. Bushels per Acre	Rainfall, Inches		Sunshine, Hours				Temperature, Mean		
		April	May and June	April	May and June	July	August	April	May	June
1923	*nil*	1·5	2·3	115	282	224	257	45·1	49·3	53·7
1925	*nil*	1·7	2·6	140	464	184	133	44·6	52·8	59·1
1922	+ 5·6	3·5	2·6	150	509	149	127	41·7	55·2	57·0
1926	+ 1·7	3·0	4·9	108	335	151	195	48·0	50·1	55·6
1924	− 4·6	3·2	6·6	157	391	236	169	44·8	53·1	57·7

The remarkable depression obtaining in 1924 was not confined to Rothamsted, it was seen at most centres.

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Influence of Soil, Season and Manuring on the Quality of Barley Grain

Of the various indications of quality, percentage of nitrogen in the grain is one of the best: as a general rule, grain with low nitrogen-content is of higher quality than grain with high nitrogen-content.

Effect of Conditions on the Nitrogen-Content of the Grain

The general average per cent. of nitrogen in the dry grain is 1·5, but the values range from 1·13 to 2·44.

The two most important factors determining nitrogen-content are:

(1) Place, which includes soil and the prevailing climate.

(2) Season, which expresses the weather variations between one year and another.

PERCENTAGE OF NITROGEN OF GRAIN FROM EACH CENTRE. AVERAGE OF ALL PLOTS, 1922-1926

	1922	1923	1924	1925	1926
Black Soils—					
Eye . . .	2·13	...	...	...	...
Walcott . .	1·80	1·80	1·58	...	...
Light Sands (Dry conditions)—					
Orwell . .	1·51	1·93	1·52	2·28	...
Woburn . .	1·95	1·71	1·23	2·01	1·57
Light Loams (Dry conditions)—					
Wellingore (Lincoln Hth.)	1·79	1·44	1·42	1·52	1·38
Norfolk Centres	1·65 (D)	2·01 (D)	1·32 (N)	1·65 (S)	1·54 (F)
Wye . .	...	...	...	...	1·48
Sand and Loam (Moist conditions)—					
Chiselborough .	...	1·50	1·46	1·55	1·49
Dunbar . .	1·44	1·71	...	...	1·53
Porlock . .	1·44	1·71	...	...	1·53
Medium to Heavy Loams (Moist conditions)—					
Cawkwell. .	1·52	1·49	1·22	...	1·69
Beverley . .	...	1·34	...	1·55	1·53
Rothamsted (Heavy). .	1·62	1·61	1·56	1·62	1·62

D = Dereham. F = Fakenham. N = Newton St Faiths. S = Sprouston.

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The Place Factor.—High percentages of nitrogen are obtained in the black soils of Eye and of Walcott ; low percentages on the moist, stony soil of Porlock ; medium percentages on the medium and heavy loams ; and variable percentages, sometimes high and sometimes low, on the sands. Typical results are given in the Table on page 39.

The most important results are those for the light soils ; these fall into three groups :

(1) Light sandy, very dry district, therefore tending to dry out : the lightest, Orwell ; less light, Woburn. Here the percentages vary much ; at Orwell they were 1·5 in 1922 and 1924, but 1·9 and 2·3 in 1923 and 1925 respectively. At Woburn they were 1·23 in 1924 ; 1·6 in 1926 ; but 1·7, 1·9 and 2 in 1923, 1922 and 1925 respectively.

(2) Light loams in dry districts. The percentages vary less from year to year, but they still show some range : at Wellingore, on the Lincoln Heath, they were 1·79 in 1922 ; 1·52 in 1925 ; but round about 1·42 in 1923, 1924 and 1926 ; at the Norfolk centres (unfortunately it was not possible to retain one centre throughout all the period) they were 2·01 in 1923 ; 1·65 in 1922 and 1925 ; 1·5 in 1926 ; but 1·3 in 1924. At Wye, Kent, 1·7 in 1924 ; 1·6 in 1926 ; and 1·4 in 1925. At the Shropshire centres : 1·9 in 1922 ; about 1·55 in 1924 and 1925 ; but 1·36 at Eyton in 1924.

(3) Sandy or stony soils or loams in moist districts or districts of low evaporation. The percentages vary still less from year to year and the value is below the average for the above : Chiselborough (loam), between 1·46 and 1·55 in the four years 1923-1926. Dunbar (sand), 1·7 in 1923, but 1·44 and 1·53 in 1922 and 1926 respectively. Porlock (stony soil), 1·2 and 1·3 in 1925 and 1924 respectively.

On the medium and heavier loams the nitrogen-content is less variable than on the light loams. On the medium loams of the Lincolnshire and Yorkshire wolds the percentage of nitrogen shows some fluctuation. At Cawkwell (Lincs) it varies from 1·2 to 1·5 ; at Beverley (Yorks), from 1·3 to 1·5 ; on the heavier loam of Rothamsted the variation is smaller : in the five years it has varied only from 1·53 to 1·62.

The *high* nitrogen percentage is associated with dry conditions in May and June, while the *low* nitrogen percentage is associated with wet May. This rule is found to hold at all centres : it is seen most clearly at Orwell and Woburn, where the percentage of nitrogen is most variable, but it also holds where the variations in nitrogen percentage are quite small, as at Chiselborough. At Orwell, 1925 and 1923 are years of high nitrogen percentage, with dry May and June, while 1922 and 1924 are years of low nitrogen percentage and wet May and June. At Wellingore the year 1922 stands out sharply from the rest with a severe May and June drought and a high nitrogen percentage. In the other years the nitrogen varies but little from the 1924 figure ; in each of these the May rainfall is of the same order.

Time of Sowing.—There is, however, another factor that affects the

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nitrogen-content on light soils, but not so much on heavy ones—the time at which the barley is sown ; the *high* nitrogen-content being associated with the *late* sowing and the *low* nitrogen-content with *early* sowing.

The dates of sowing on the light soils of the preceding Tables are :

Year	*Nitrogen per cent.*	*Walcott*	*Wellingore*	*Dates of Sowing*		
				Cawkwell	*Woburn*	*Orwell*
1922	High	Apr. 3	Mar. 22	Apr. 24	Apr. 19	Apr. 29[1]
1924	Low	Mar. 10	Mar. 13	Mar. 25	Mar. 11	Apr. 7

From the foregoing it appears that the percentage of nitrogen in the grain is, in the main, determined by June, and it should not be impossible to devise means whereby an estimate could be made then of its probable amount.

The effect of fertilizers on nitrogen-content is less than that of either soil or season. The effect of nitrogen fertilizers is, perhaps, the most important : it varies with the size of the dressing. In small quantities sulphate of ammonia lowers the nitrogen-content of the grain. There is a certain size of dressing that has little or no effect on nitrogen-content ; larger dressings increase it. This safe or harmless dressing of sulphate of ammonia is larger when superphosphate and potassic sulphate are given than when the sulphate of ammonia is given alone, and even when these fertilizers do not increase the yield they may ensure against a fall in quality. Of the two, potassic fertilizers seem to have the most potent effect in lowering the nitrogen percentage.

Valuation of Barley

The valuation put on the barley by the buyer seems to depend more on the soil and the climate than on anything the farmer can do. Although most soils can produce good sound barleys in certain seasons, only the light loams produce high-priced barleys every year, and even on these the barley of any particular farm may have low value because of damage at or after harvest. Barleys grown on light sands may be valued higher or lower than those grown on loams. There is a wide variation from season to season—in some years they are valued higher than the valuation of the malt appears to justify. Barleys grown on chalk loam may be valued below what their malting history justifies. On the average the barley buyer comes out right, but the chalk farmer may lose.

[1] 1925.

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The justification for paying so much attention to the nitrogen-content of the grain is that it is closely related to valuation. The higher the nitrogen-content of the grain the less the buyer will pay for it, and a comparison of the analytical figures with the valuation shows that the buyer may deduct as much as 2s. 9d. per quarter for an additional 0·1 per cent.—one-tenth of 1 per cent. The high nitrogen barley has the disadvantage of giving a low extract in the malt, and also of leading to certain fermentation troubles; hence the brewer prefers a grain with lower nitrogen-content.

THE DISCUSSION

Lieut.-Col. Sir Archibald Weigall, Chairman of the Conference, in opening the proceedings, stated that the barley crop, if successful, was one of the most profitable crops for an arable farmer. It was most essential that growers and buyers should come to a thorough understanding with one another, and this especially applied to districts, since the requirements of buyers in one district differed from those of another. Any information therefore which could be given, both with regard to the cultivation and manuring of the crop, would prove of the utmost value. In referring to land under cultivation for barley, Sir Archibald remarked that it was a significant fact that the average return of sugar-beet was increasing each year.

Dr E. S. Beaven (Warminster), in referring to phosphatic and potassic fertilizers, said that it was not the usual practice of growers to apply these to their barley, for the reason that they had in all probability given the root crop a good dressing of both. What they more often did apply was either sulphate of ammonia or nitrate of soda. The results of the manurial experiments described by Sir J. Russell had been generally confirmatory of the conclusions drawn by Munro and himself thirty years ago, which were based on examination of Rothamsted samples grown in Agdell field. The permanent plots on Hoos Field at Rothamsted were primarily a demonstration of the effects on the crop of phosphatic starvation, and showed clearly that such starvation was inimical to malting quality. With reference to the experiments on the use of ammonium chloride, he wondered whether there would be any deleterious effect after a certain time. The general effect of acid-soil conditions on barley was such that he felt more attention should be given to the study of the effects of lime and chalk. Locality and climate were probably the two most important factors in the growing of barley. There was no such thing as a best barley, but some varieties responded better on some soils.

Mr F. Rayns (Norfolk Agricultural Station) stated that on his farm, and also on many farms in Norfolk, the application of phosphatic

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fertilizer resulted in a distinct increase in yield. There were, however, certain areas on which phosphatic manure seemed to have very little effect, but a marked benefit resulted from the application of potash. There were many farmers who advocated the dressing of barley-land with potash on account of the benefit which occurred to the following hay crop. Too much importance could not be attached to all operations of cultivation, and to the uniformity with which they are carried out. Some farmers ploughed their barley-land three times in order to ensure, as far as possible, a uniform seed-bed. The distribution of the seed was another important factor, and this distribution was often made more even when sainfoin was undersown, since this necessitated drilling in two directions.

His objection to autumn sowing of barley was that one had not the same opportunity for cleaning the land prior to sowing the seed, as in the case of spring-sown barley.

The cutting of barley was always a most vexing question, and he doubted if more than a small percentage of growers were always sure in their own minds when to cut the crop. It was a matter in which experience and local climatic conditions were the predominating factors. The tendency was, however, to cut too early.

A. Chaston Chapman, F.R.S. (London): I should like to raise the question of the character of much of the barley produced in the present day in relation to the yeast-feeding properties of the malts made from it. As compared with the barleys grown years ago the amount of total nitrogen in the bulk of the malting barley now produced is small, and the same, of course, applies to the amount of soluble non-coagulable nitrogenous matters communicated to the wort, on which the yeast has to rely for its nitrogen nutrition. For nearly thirty years I have been in the habit of making this estimation in the case of every sample of malt submitted to me for analysis, and the estimations therefore amount to many thousands. I was induced to do this in the early days because I felt convinced that the numbers ought to be of some value, and as time went on I began to see that they did, as a matter of fact, furnish additional information as to the actual brewing-value of samples of malt. It is clear that without an estimation of the different forms of nitrogen occurring in the wort it is impossible to say with certainty what proportions of these substances are available for purposes of yeast nutrition. With existing methods, such differentiation is at present impossible in technical analysis, but my very extensive experience over many years has shown me that in the main the total soluble nitrogen percentage does afford an indication of the yeast-feeding properties of the malt.

I should, perhaps, say in passing that the relative importance of the different classes of nitrogen is at present receiving attention under the Institute of Brewing Research Scheme. When the percentage is low

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—say 3 per cent.—the yeast-feeding properties of the malts in question are found in practice to be poor, whereas when the percentage is higher —say, in the neighbourhood of 4 per cent.—much better results from the point of view of yeast nutrition are obtained in the brewery.

The present lower original gravities naturally make matters worse, and my wide experience has convinced me that many of the brewers' worst troubles arise from the under-nutrition of the yeast. I think it is a question for serious consideration whether the barley breeder and the farmer have not already unconsciously gone too far in respect of nitrogen reduction. The complaints made years ago that the barleys were too nitrogenous were frequently exaggerated, and would scarcely have been made to-day with our better understanding of brewing science. In brewing everything depends on the vigour and proper nutrition of the yeast, and this naturally can be secured only if the wort contains a sufficient quantity of nitrogen of the right kind.

Mr Stanley Taylor (Bath) said that he did not agree with Mr Reid in considering the Chevallier type the best barley for maltsters; he preferred Archer or Archer-Spratt. Neither could he agree that foreign barley was essential for drainage purposes. He maintained that the six-rowed winter barley which is used could be improved upon by plant breeders, so that it would give the drainage required. He would like to ask Mr Joyce which rotation produced the best quality barley—after ley, straw, or roots? Mr Taylor said that in his opinion the sum-total in the poundage of brewers' extract had been considerably increased, due, he thought, to the production of the Archer types of barley, and that the farmer has produced more barley from the same number of acres. He did not think that increase in extracts was due entirely to an improvement in the maltster's art.

Mr Reid, in replying to Mr Stanley Taylor, said that as Archer was an ancestor of Spratt-Archer, there could not be any conflict of opinion. With regard to foreign barley for drainage purpose, Mr Reid said that he quite agreed that such barley should be grown here, and pointed out that experiments were in progress having as their object the possibilities of opening up the new field.

Mr Joyce (Somerset) said, in reply to Mr Stanley Taylor's question, he had found that on his land the quality of the barley after roots folded with sheep was not so good as after ley or cereals.

Mr Newman (Institute of Agricultural Engineering, Oxford) suggested that the use of a combine harvester would not only reduce the cost of harvesting, but would also diminish the risk of weather damage when the crop is ripe—the most serious and the most annoying risk to which the barley grower is liable.

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There was a general impression that the grain in this country is rarely dry enough to allow the use of these machines. To test this point, last year samples of wheat and barley were taken from ripe standing crops, and tested for moisture-content in the laboratory at the Institute of Agricultural Engineering. In both crops it was found that once the grain was really ripe the moisture-content on any dry day was below 20 per cent., and the grain accordingly threshable. Some of the tests gave figures as low as 17 per cent. moisture-content.

In such a season as last it is probable that some subsequent drying would be necessary, but that presents no special difficulty, and in ordinary seasons it appears that the combine harvester could be used, and would deliver a dry sample.

The Institute is importing a combine for use next harvest, and it is intended to try it on barley as well as the other main crops.

Sir JOHN RUSSELL, in summing up the discussion, emphasized the fact that there was no such thing as a best barley, since maltsters and brewers' requirements varied somewhat from one district to another, and, in addition, the effects of soil and climate—and, to a lesser extent, manuring—were themselves variable, as appeared both from Mr Stewart's paper and the results obtained at Rothamsted. In manurial treatment it seemed clear that it was essential for phosphate in some form to be present in the soil; an absence of any increase in yield or improvement in quality, resulting from the addition of phosphate manure, was not a safe guide that phosphate was not needed. There was no danger from the use of ammonium chloride in place of ammonium sulphate; the amount of chlorine released was very little, and this was rapidly washed out of the soil. Finally, he stressed the importance of all cultivation operations if a uniform crop was to be secured.

GENERAL SUMMARY OF PAPERS AND DISCUSSION

By DR KEEN, D.Sc., F.Inst.P.

(1) In the past seven years the area under barley has decreased by 760,000 acres, representing about 2,850,000 quarters. In 1927, 1,250,000 acres were under barley. In 1913, 6,000,000 quarters were malted, and the figure steadily fell to about 3,500,000 in 1926—of this less than 2,750,000 was home-grown. The average yield in a good year is about 4,000,000 quarters.

(2) The grower of malting barley is concerned with both yield and quality, while the maltster and brewer are concerned with the quality only.

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Factors affecting Yield

(3) *Soil.*—As with nearly all other crops, the effect of soil is very marked. Moist sands give the largest yield, followed in order by light loams, heavy loams, and dry sandy soil.

Season.—Wet seasons appear to give an increased yield ; abnormally wet years and dry seasons reduce the yield. Sunshine is relatively unimportant until the ripening period begins, and excess rainfall in August produces much damage. Rain in May and June largely offsets the damage from spring drought.

Fertilizers.—An application of 1 cwt. of sulphate of ammonia gives an increase of about 6 bushels in almost all conditions, while muriate of ammonia gives somewhat more. The increase is due to the greater number of grain-bearing heads and not to the greater number of grains per head. The effect of potassic fertilizers depends on weather conditions : they are most useful in the years when ripening is delayed. A surprising result was obtained in 1924, when the yield was lowered by potassic fertilizers. The effect of phosphatic manures is complex. In some cases the yield was reduced on light soils, due, possibly, to too-rapid ripening.

Factors affecting Quality

(4) The outstanding factor of quality is the percentage of nitrogen in the grain. In general, the quality falls off with increasing nitrogen-content. Values in excess of 1·5 to 1·6 per cent. are undesirable.

Soil.—Heavy and rich soils give, in general, higher percentages of nitrogen than the lighter soils, on which the results are more variable.

Season.—This affects particularly the lighter soils. Prematurely ripened barley—the effect of drought—has low moisture-content (13 per cent. instead of the usual 16 per cent.), and nitrogen-content usually above 1·7 per cent. A wet period in May results in a low nitrogen percentage. In prematurely ripened grain the basal bristle is often not attached to the corn, the skin is open at the base, and absence of this natural protection results in lower vitality, and in mould development in malting. Unduly wet seasons produce both unripe and overripe, or "washed," barley. The lattter is black and weathered in appearance, the skins are slack, and the nitrogen-content may range from 1 per cent. in the " washed " grain to 2 per cent. in the unripe grain.

Fertilizers.—Contrary to earlier ideas, moderate top-dressings of nitrogen fertilizers — about 1 cwt. of sulphate of ammonia or its equivalent—have little or no effect on nitrogen-content. The top-dressing can be further increased if phosphatic and potassic fertilizers are also given, and the minerals also prevent any fall in quality.

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Cultural Practices

(5) The details of farmers' practices in growing malting barley vary greatly according to soil, district and rotation, and cannot be summarized. Great importance is attached to a good tilth in the seed-bed. Although both heavy seeding and fairly deep sowing are general—on the grounds that tillering and second growth is discouraged and the seed is protected against weather and birds—shallow and thin sowing is also advocated. It is claimed that the early and extensive tillering which results, gives more uniformly ripened grain and a stronger straw; its possible disadvantages are bird depredations and damage from frost or drought in the early stages. The value of autumn sowing needs further investigation. In general, delay in sowing affects the quality more than the yield. Early-sown crops also escape the gout-fly. Uniformity in all stages of growth is important, and can be largely secured by adequate seed-bed preparation, and uniform distribution of seed and manures.

There is evidence from Lincolnshire that the quality of barley grown on the light land is improved if the seed is obtained from the crop grown on adjacent colder heavy land.

Barley is commonly cut too soon; if ripening has been uneven it is better to wait, even at the risk of losing ears or shed corn. Great care is necessary in harvesting.

Varieties of Seed

(6) The famous improved narrow-eared barley named after Chevallier appeared about a century ago. It was later eclipsed by Archer, which gave a high yield, with a short, strong straw and a short neck, so that ears did not break off. Its grain was inferior in appearance to Chevallier, but malted well.

Of the broad-eared varieties that suit rich heavy soils the ancient Spratt form is still grown in the Fens. They tiller abundantly and have strong straw. Goldthorpe, found in a field of Chevallier in 1889, proved a high yielder of excellent quality and ripened about ten days earlier than Archer, but its brittle neck was a drawback.

These original forms have been eclipsed by two hybrids now in very general use, Plumage-Archer and Spratt-Archer.

Plumage-Archer is a broad-eared type, resembling Goldthorpe, but with stronger neck. It does well on heavy soil.

Spratt-Archer was developed for wet and sunless conditions. It has a strong straw and ripens early.

Both forms are high yielders of excellent malting quality. Spratt-Archer is slightly better in yield, and Plumage-Archer in malting quality.

It appears that 60 to 70 per cent. of seed is home-grown, or sold from farmer to farmer, and the question arises whether, in the farmers' interests, some form of regulation to ensure a certified seed-supply is desirable.

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The Buyer's Requirements

(7) In attempting to estimate quality buyers have developed certain standards of judging. In the present state of knowledge these standards are stated to be : barley of Chevallier class, grown on barley-land, well ripened, sound and uniform, of good shape, carefully threshed and free from weed contamination, with nitrogen-content not exceeding 1·6 per cent. Undesirable features are : hard, steely and heated grain, badly threshed, skinned and broken corns, grown corns, and high nitrogen-content. The valuation seems to depend more on soil and climate than on the cultural practices of the power.

The nitrogen-content is the most important single factor. High nitrogen barley gives a low extract in the malt and leads to fermentation troubles in the brewery. There is evidence, however, that the yeast-feeding properties of malts from low nitrogen barleys are poor, and as the vigour and proper nutrition of the yeast is of prime importance in the brewery, especially with the present lower specific gravities, the significance of the nitrogen-content needs further investigation. In this connexion the kinds and amounts of soluble non-coagulable nitrogenous compounds communicated to the wort constitute an important field of study.

It is stated that to secure a bright and clear bottled beer a certain small proportion of foreign sun-dried barley is desirable, and, further, that a small amount of foreign husky barley is useful in the brewers' mash for drainage.

Correspondence between sample and deliveries is essential. The best method of sampling is to place, in a spare sack, a handful out of each sack as it is filling. The sample is then thoroughly mixed. If the whole consignment is sent off as sacked, without mixing and winnowing, the sample sack, although fairly representing the purchase in bulk, will not correspond with each individual sack. To avoid misconception the buyer should be informed which method has been adopted.

The value of the grain will be diminished if, in threshing, the " ile " or beard is cut too short, as the adjacent skin is liable to be stripped off. If too much of the beard is left, however, the grain looks less plump, and this may adversely affect the valuation, although its actual malting-value is not affected.

Printed in Great Britain
by The Riverside Press Limited
Edinburgh

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