ROTHAMSTED CONFERENCES

IV. THE CULTURE AND MANURING OF SUGAR-BEET

Contributions by

J. M. VAN BOMMEL VAN VLOTEN; T. G. FOWLER; C. HEIGHAM, M.A.; H. J. PAGE, B.Sc., A.I.C.; I. J. SCHAPRINGER; C. J. CLARKE; R. N. DOWLING, N.D.A., P.A.S.I.; and others

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THE CULTURE AND MANURING OF SUGAR-BEET

BEING THE REPORT OF A CONFERENCE HELD AT ROTHAMSTED ON JANUARY 19TH 1927 UNDER THE CHAIRMANSHIP OF

THE RIGHT HON.

LORD CLINTON, D.L., J.P.

With Contributions by

J. M. VAN BOMMEL VAN VLOTEN : T. G. FOWLER : C. HEIGHAM, M.A. : H. J. PAGE, B.Sc., A.I.C. : I. J. SCHAPRINGER : C. J. CLARKE R. N. DOWLING, N.D.A., P.A.S.I.

etc., etc.

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CONTINENTAL EXPERIENCE WITH THE GROWTH OF SUGAR-BEET

By J. M. VAN BOMMEL VAN VLOTEN

Expert to the Netherland Sugar Industry

When I received by intermediary of the Dutch Department of Agriculture your invitation to speak before this conference about some questions concerning sugar-beet culture, I at first hesitated to accept it. In the first place, I wish to state that it is very difficult for me to speak in a language which is not familiar to me, and in the second place, the circumstances in England are so different from those in Holland that I can hardly be expected to be an expert for your country.

However, the consideration that sugar-beet culture is rather a new one in England, and the fact that I greatly appreciated the honour conferred upon me by asking me to speak before this conference, made me decide to accept your invitation.

In a paper read by Mr Alfred Wood, Secretary to the British Sugar Society, to a meeting of the Farmers' Club, in March 1925, he explained how sugar-beet culture and sugar industry are dependent on each other. He has called the ten years during which the subsidy is given to the British sugar industry, an educational period for the farmers. It seems to me that he is quite right, and that during these ten years not only your practical farmers and your labourers must gain the experience by which the best results will be obtained, but that also your British agricultural scientists must prepare, by several researches, for the time when your sugar industry will have to face the competition of the production of other countries.

It is about these researches that I should like to speak to you.

In your country you have the advantage that from the very beginning you can profit by the experience of the Continent. Now the question is whether this "Continental" experience will be of value to you or not. The varieties of seed used on the Continent—are they suitable for your circumstances? Would the distance between the drill rows, which has proved to be efficient on the Continent, prove also to be appropriate for England? And then there is finally the important question of manuring, which depends so much on local circumstances.

First of all I will treat the question, which variety of seed is to be chosen.

The choice of the variety of seed is, as far as I know, not yet a problem which is very much discussed by the English farmers. The seed is provided by the factory and the farmer does not influence the choice. Yet it is of great importance to him that a variety is chosen which will suit him best.

SCHEME I

6	1
5	2
4	3
3	4
2	5
1	6
6	1
5	2
4	3
3	4
2	5
1	6
6	1
5	2
4	3
3	4
2	5
1	6

On the Continent, yearly, a great number of experiments are made by which different varieties are tested on yield and sugar content, for the choice of the variety can be made only if the results of careful and scientific experiments are known.

Therefore I will begin to tell you briefly how the experiments are made in Holland. A field is chosen in which the soil can be considered to be homogeneous. The number of varieties to be compared is about six. The field then is divided into 36 plots in the way as shown in Scheme I.

Those 36 plots are marked out on the field, each consisting of five rows of 100 beets. They must be rather small, otherwise the total of the experimental field will be too large, and the danger of the soil not being homogeneous will be greater. This is also the reason why no larger number of varieties can be compared.

The seed is sown by hand, the little hand-drills not being so suitable for this work.

By sowing the varieties of seed in this way they will all be distributed nicely over the field, and the influence of the soil is eliminated as much as possible. After sowing is done the most careful attention must be given to the crop to prevent sugar-beet being missing. Each missing root influences the results of the experiments.

In October the yield of each plot is weighed and the middle row is transported to a factory where the tare and sugar content are determined.

Of each variety about 600 beets are tested on sugar content. It is of great importance that the transport to the factory and the determination of the sugar content is done as quickly as possible, to avoid alterations on account of drying out or other causes.

The average weight and sugar content of the six plots of each variety is calculated, and conclusions drawn in the modern scientific way. If there is no good conformity between the results of the six plots of each variety it is advisable to consider the experiment to have been a failure.

It cannot be sufficiently emphasized that the experiments on sugar-beet culture must be made very carefully, for otherwise there is a great risk that wrong conclusions will be drawn.

The experimental commission of the Netherland sugar industry each year has, besides making experiments, about eight of these experimental fields in various parts of the country, all surveyed by two agricultural specialists who are solely in their service.

The results of the experiments have always shown that there is a great difference in quality between the various varieties of beet seed which can be bought. Several Continental producers of seed select their varieties in three directions, and by doing so they enable the factories to choose those varieties which are esteemed to be the most

efficient for the special circumstances under which their farmers are living.

These three types of varieties are frequently indicated by the letters E, N and Z.

E is a type giving a great yield with a low sugar content, whereas the Z type contains more sugar but yields a smaller weight. The type N (normal) stands, concerning sugar content as well as yield, between the types E and Z.

The question, which of these types is to be preferred, is much discussed. The answer depends not only on circumstances of soil and climate but also on the opinion of the farmers and the manufacturers. The opinion of the farmer and the manufacturer is often divided about this subject. The way in which the sugar-beets are paid for is closely connected with this problem. I shall deal with this question afterwards, when I shall be speaking about the subject: how in general the results of experiments must be judged.

An important matter which also can be solved by these experimental fields is the inclination of the different varieties to run to seed. The forming of bolters not only depends on conditions of growth but without a doubt is a hereditary property of the variety.

In Holland, for each variety the percentage of the roots which run to seed is determined, and I dare say that every year always the same varieties show the largest number of bolters.

It is my deliberate opinion that the producers of seed must be able to reduce the forming of bolters to a minimum.

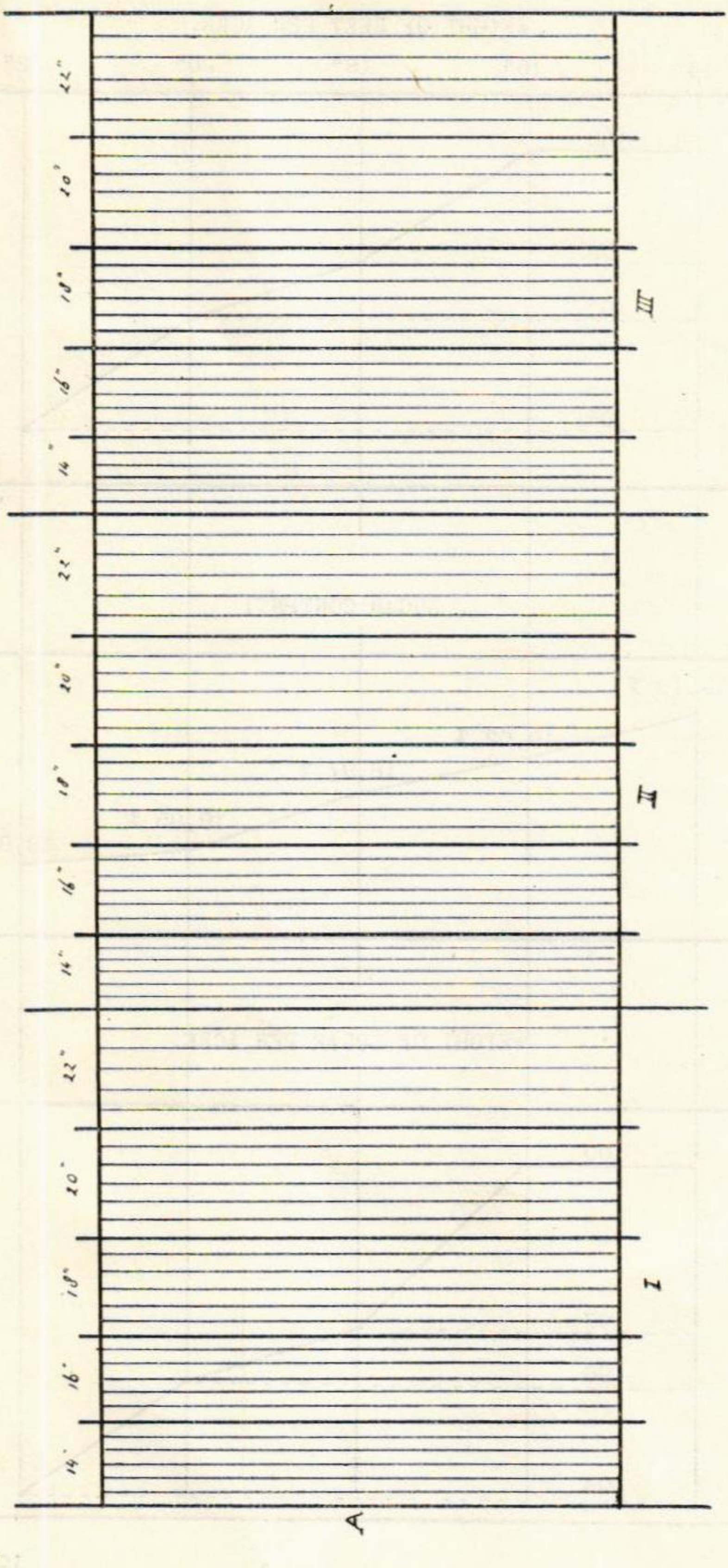
Out of the circumstances which influence the choice of the variety I shall only mention the soil. It is a matter of common knowledge that there are some soils which give a greater yield and a lower sugar content than others—I think the Fen district is a part of your country where such soils are found. I would advise not to choose for these soils the varieties of type E, because the beets, in all likelihood, would not be of high quality.

I shall now pass on to the second problem which I mentioned—the distance between the drill rows. Perhaps this problem is of peculiar importance for the English farmers, because I have the impression that drilling is too wide in England.

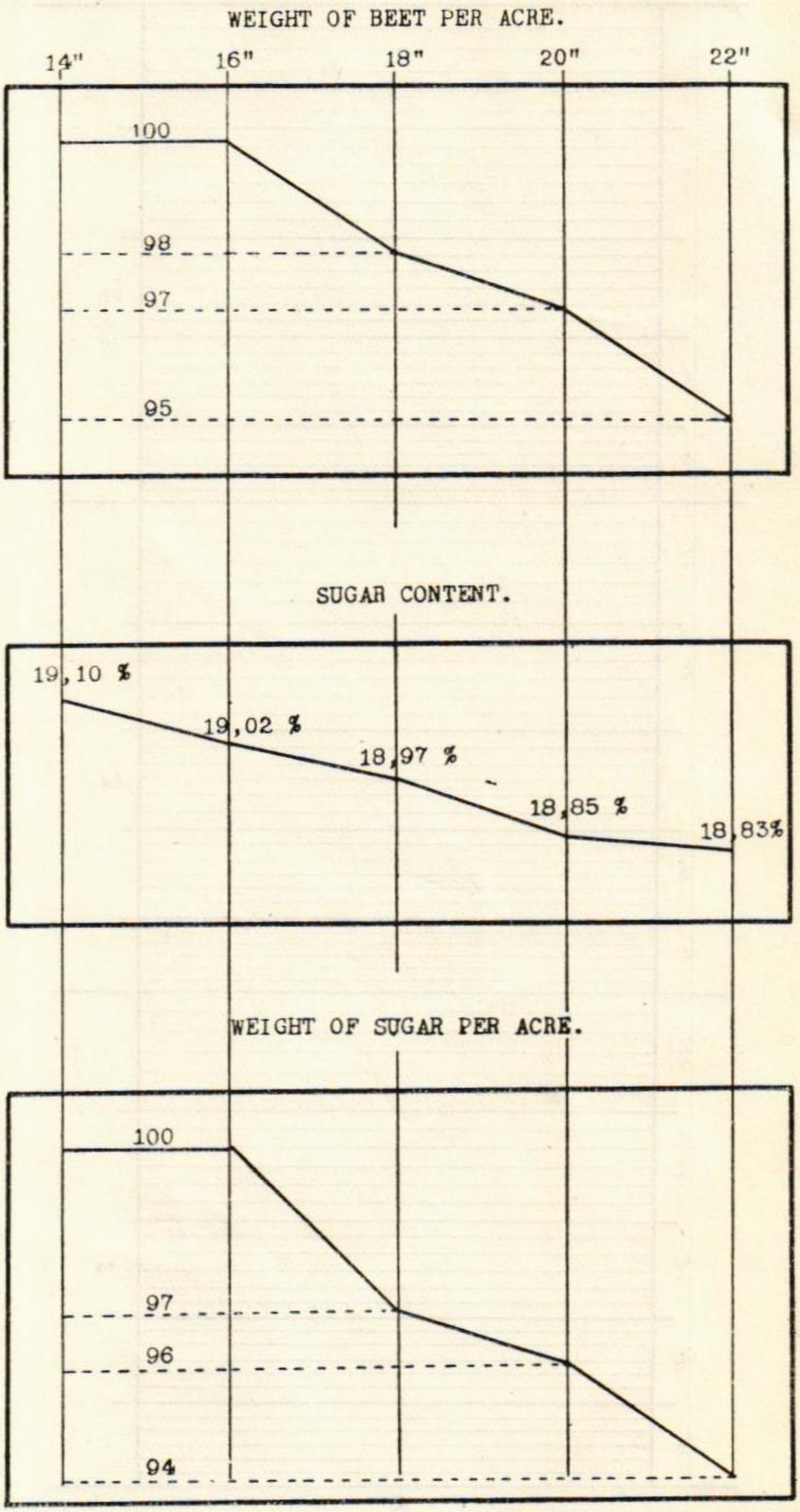
Wide drilling gives the advantage that horse-hoeing can be done easily and as long as possible. The number of rows is smaller; bunching, singling and also the lifting and topping of the beets will require less labour; on the other hand, however, the wider the drilling is done the lower the yield and the sugar content, and the larger the roots will be. But the increase of the weight of each root does not counterbalance the decrease of the number of beets.

In Holland we have drills covering about 6 ft. and fitted with five or six coulters, which means a distance between the rows of about 16 in. and 13 in.

SCHEME II



SCHEME III


WEIGHT OF BEET PER ACRE.
14"
16"
18"
20"
22"
100
98
97
95
SUGAR CONTENT.
19,10 %
19,02 %
18,97 %
18,85 %
18,83%
WEIGHT OF SUGAR PER ACRE.
100
97
96
94

The distance of 16 in. is considered rather wide in Holland, but perhaps it is the most suitable one for your country. This must be ascertained by careful experiments.

I have no knowledge of experiments on this subject during the last years in Holland, but the Institute of the Czecho-Slovakian Sugar Industry published the results of many experiments in that country, which I suppose will interest you.

The experiments were made with the object of comparing the results to be obtained with a distance between the rows of 14, 16, 18, 20 and 22 in., and a distance between the plants *in* the rows of about 12 in.

The field was marked as shown in Scheme II. Beginning at A, at first seven rows, distanced 14 in., are marked out; then six rows follow, distanced 16 in.; then, again, six rows with a distance of 18 in., and so on. This method of marking is repeated three times.

After lifting, the five inner rows of each plot are weighed. By doing so the same number of roots of each plot is weighed, at least in theory. The yield per acre of each plot can be determined by conversion.

The average result of twenty-four of these experiments is shown in Table I and Scheme III.

TABLE I

Distance	*Weight of Beets*	*Sugar Content*	*Weight of Sugar*
14 in. . .	100[1]	19·10 per cent.	100[1]
16 „ . .	100	29·02 „	100
18 „ . .	98	18·97 „	97
20 „ . .	97	18·85 „	96
22 „ . .	95	18·83 „	94

The following conclusions can be drawn.

There is no great difference in the results of drilling at a distance of 14 or 16 in. As soon as the distance is larger, the weight of beets, the sugar content and the weight of sugar per acre are decreasing.

It is evident that the differences are not very large. The principal reason why I advised to keep small distances is that sugar-beet culture always gives the best results if an even stand or plant is obtained.

There are many reasons why the roots will grow thin and gappy: an uneven germination, a bad preparation of the soil, the wireworm and other pests are all dangers which always must be feared. The

[1] The weight of beets and the weight of sugar per areal unit, when the distance between the rows is 14 in., is supposed to be 100.

consequences of these dangers are so much the worse if the distance between the drill rows is wide.

The third question which I mentioned was the manuring of sugar-beet. As I already have said, the solution of this problem depends very much on local circumstances; and because Mr Page and Mr Heigham will speak about this question it seems to me preferable, now, to pass on to the problem of how the results of experiments in general must be judged.

The results of experiments are of consequence to the farmers as well as to the manufacturers. Both parties, however, look upon this matter in a different way. At first I shall explain how the farmer must judge the results of experiments, and then I shall speak about the standpoint of the manufacturer.

I take it that the price of 1 ton of roots, containing $15\frac{1}{2}$ per cent. of sugar, delivered to the factory sidings, is 54s., and that for each per cent. of sugar (or a fraction thereof) over $15\frac{1}{2}$ per cent. is added 2s. 6d. (or a fraction thereof).

The cost of production by the farmer, haulage and transport to the factory are supposed to be :

Cost of production per acre . .	£20	0	0
Cost of haulage per ton . .	0	4	0
Cost of transport per ton . .	0	5	0

I take it, further, that the results of the experiments are as follows :

Case I. 11 tons per acre, sugar content 18 per cent.
Case II. 11 tons 10 cwts. per acre, sugar content $17\frac{1}{2}$ per cent.
Case III. 12 tons per acre, sugar content 17 per cent.

The profit obtained by the farmer in each of these cases is shown in Table II.

TABLE II

Per Acre	I 11 *tons* 18%	II 11 *tons* 10 *cwt.* $17\frac{1}{2}$%	III 12 *tons* 17%
	tons cwt. qr. lb.	tons cwt. qr. lb.	tons cwt. qr. lb.
Weight of sugar	1 19 2 11	2 0 0 22	2 0 2 34
	£ *s.* *d.*	*£* *s.* *d.*	*£* *s.* *d.*
Gross price .	33 2 9	33 18 6	34 13 0
Cost of Production .	24 19 0	25 3 6	25 8 0
Profit .	8 3 9	8 15 0	9 5 0

It is clear that the farmer obtains the largest profit in the third case.

The yield per acre does not interest the manufacturer. He only takes into account the value of 1 ton of roots. In order to calculate the value of 1 ton of roots I take it that:

(1) The net return of sugar per cwt. is 42s.—inclusive subsidy and exclusive excise duty and all costs of selling and delivery;

(2) The return of the by-products (molasses, pulp, etc.) is 15s. per ton of roots;

(3) The waste of sugar (that is, the difference between the quantity of sugar in the beets and the quantity of refined sugar obtained in the factory) is $3\frac{1}{2}$ per cent.;

(4) The working expenses of the factory amount to £1 per ton.

The value of 1 ton of roots, then, can be calculated as shown in the following Table:

TABLE III

Per Ton	I 18%	II 17½%	III 17%
	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.
Weight of sugar . .	2 3 17	2 3 6	2 2 22
	£ s. d.	£ s. d.	£ s. d.
Return of sugar . .	6 1 10	5 17 7	5 13 5
Return of by-products .	0 15 0	0 15 0	0 15 0
Returns per ton . .	6 16 10	6 12 7	6 8 5
Working expenses and purchase price of beets .	4 0 3	3 19 0	3 17 9
Net return	2 16 7	2 13 7	2 10 8

First of all I must emphasize that this calculation is not absolutely right. The figures which I mention are based upon the suppositions which I made, and although I think that they don't deviate very much from the reality I must warn you not to consider them to be exact. I mentioned these figures only to be able to give an instance.

Moreover, the supposition that the waste of sugar and the working expenses are equal in all three cases is not right. They depend on the quality of the beets, which again depends on their purity. The prevalent opinion is that the sugar content and the purity of the juice which is to be obtained are proportional. Therefore it may be expected that the less sugar the beets contain the higher the working expenses and the waste of sugar per ton will be. Mr Fowler will be more able to treat of this question than I.

Anyhow we may say that for the manufacturer there is a difference in value between the beets of 18 per cent. and 17 per cent. of at least 5s. 11d. per ton in the circumstances which I mentioned; so the manufacturer will prefer Case I., whereas the farmer obtains the largest profit in Case III.

In looking upon this matter neither from the standpoint of the farmer nor from that of the manufacturer, but in a general way, obviously the results of experiments can be judged only by combining both calculations which I made. By doing so we consider sugar-beet culture and sugar industry as *one process of production, and I think that this is the only way in which the most efficient method of sugar production can be found.*

It would carry us too far to make these calculations, and, for the present, they are not of much importance for the English farmers, because neither the farmers nor the manufacturers combine sugar-beet culture and sugar industry in this way : they both look only for their own interests. In Holland, where the greater part of all sugar-beets are delivered to co-operative factories, the combined calculation is of more importance.

So the farmers in England, in judging the results of experiments, have to make the calculation which I showed you in Table II., and it is clear that it pays them best to grow beets giving a larger yield, with a smaller sugar content. It is a matter of fact that it is easier for the farmer to increase the weight of sugar per acre by growing these beets than by growing beets which contain more sugar.

For instance, by augmenting the quantity of nitrogenous manures the farmer is able to increase his crop. By doing so, however, the sugar content and the purity of the beets decrease, which is against the interest of the manufacturer. If the manufacturer wants the farmers to grow beets of high quality, with a good sugar content and purity, he must enable them to do so by paying for it.

When studying your sugar-beet contract it struck me that the farmer is not sufficiently paid for rich beets in proportion to beets of lower sugar content. For the first $15\frac{1}{2}$ per cent. of sugar 54s. is paid —that is, 3s. 5d. for each percentage—whereas for the percentages over $15\frac{1}{2}$ only 2s. 6d. is paid, notwithstanding that these percentages are of greater value to the manufacturer. It may be possible that the calculation of Table III. is not entirely right—the working expenses may be higher or lower, or there may be other reasons—but in any case this will not influence the *difference* which exists between the value of the various types of beets.

This calculation proves that the difference between the value of beets of 17 per cent. and 18 per cent. must be at least 8s. 5d.—of which the farmer receives only 2s. 6d.

It may seem that by making these remarks I have wandered from my subject, but I considered it worth while to make them because

I am convinced that only by a good method of payment of the sugar-beets can be brought together the divergent interests of the farmer and the manufacturer. Only if there is no large contrast between these interests can be found the most economical method of sugar production.

The last problem on which I should like to fix your attention is the question of the ripening of the beets.

Unripe beets contain less sugar, and their purity is low. The property of early and late ripening of the beets not only depends on conditions of growth, but also seems to be a hereditary property of the variety. At least, the producers of seed assert that the varieties of type E are late-ripening and that the Z types ripen early. I have no knowledge of experiments proving that this is right.

As to the conditions of growth, I will remark that large dressings of nitrogenous manures—and especially late top dressings—cause late ripening of the beets. It seems to me of interest to the farmers as well as to the manufacturers that, for the first deliveries to the factories of each campaign, beets are chosen of Z varieties, and that in any case no beets are chosen to which late top-dressings of nitrogenous manures have been applied.

I think that I ought now to finish, for the time which is reserved for my paper is over. I hope that what I have told you about experiments on sugar-beet culture and how to judge beets has interested you, and that it will contribute to the development of your sugar production.

I have still to make a request. If there are gentlemen who would like to ask me some questions I shall gladly try to answer them. But please speak as distinctly and slowly as possible, because it will be difficult for me to understand.

WHAT THE FACTORY WANTS AND HOW THE FARMER CAN SUPPLY IT

By T. G. FOWLER

Cantley Beet-Sugar Factory

The title of this paper was given to me by Sir John Russell, but I should have preferred to have designated it under a broader title.

You will readily apprehend that this subject can be discussed from two chief points of view. Firstly, the ideal mechanical and chemical aspect from the purely selfish manufacturing point of view of the manager of a sugar-beet factory ; and secondly, from the commercial standpoint as it influences the purchasing, transporting and manufacturing of the sugar-beet into sugar, pulp and molasses, and the marketing of these finished products.

I do not propose to touch upon the first point, as I fear to frighten farmers away from producing sugar-beet altogether, and to deprive a large body of men from earning an honest livelihood who at present use their brains and labour in producing machinery, both mechanical and chemical, for combating the various difficulties which are to be met with in the farm and in the factory in the production of beet-sugar.

I shall endeavour to explain the commercial side of the English sugar-beet industry on a broad basis gleaned from the comparatively short experience I have gained at Cantley since 1920, and quite realize I am probably laying myself open to severe criticism from those who have enjoyed as many years experience in the industry as I have years of life.

Although I realize that this conference is to-day chiefly concerned with the production of sugar-beet on the farm, I think it will not be out of place to touch briefly on the marketing of the sugar-beet, as there are probably several farmers here to-day who have never grown sugar-beet, and before they commence to do so would, I imagine, naturally desire to know under what terms and conditions they can sell their sugar-beet crop.

Up to the present—and I imagine it will always remain so—sugar-beet growing is not undertaken by a farmer until he has first made a contract with a factory for a specified acreage for a period of one, two or three years.

Unlike the production of barley, wheat, potatoes and fruit, etc., there are few markets for sugar-beet, so unless a farmer enters into a contract with a factory before he drills his crop he has no market for his crop other than as a medium for converting his stock into meat. Similarly, a factory, in order that the necessary coal, limestone, bags, etc., can be purchased, and the factory plant put into order for the ensuing cutting season, must know, approximately at least, some six months before the crop is ready to harvest the quantity of beet it will have to deal with in a season.

Therefore the factory and the farmer frame a universal contract covering one or a series of years, and the term and conditions under which the beet will be delivered to and paid for by a certain factory. Such contracts are either offered by the factory subject to acceptance or rejection by the grower, or are arrived at after collective bargaining by the factory with a representative body such as the headquarters of the N.F.U.

I know only too well that the farmer all over the world enjoys a day out at a market, and a deal, and for many years I honestly believe many farmers did not grow sugar-beet, or as big an acreage as they were able to do, purely because the selling of sugar-beet was so dull—a few strokes of the pen and your signature and it was all over, and you were tied up for one or several years. A few adventurous farmers have experimented in growing without a contract, with the prospect

that they might find a factory willing to offer them a higher price during the cutting season, but I am afraid they have always met with bitter disappointment, as this practice, if generally adopted, would soon land the industry in difficulties.

The contract requires the farmer to grow a specified acreage of sugar-beet from seed supplied by the factory, and deliver all the crop from this acreage to the factory in a reasonably clean state and in a perfectly sound, healthy condition. The factory reserves the unqualified right to supply the seed, though quite prepared to permit the grower to choose one or any of the chosen varieties recommended and purchased by the factory.

It is vitally important to the factory and to the grower that only the best seed should be used, and if the choice of seed was left to the inexperienced farmer the result would invariably be disastrous, for many farmers would be induced by gullible and well-meaning salesmen —who themselves are not in a position to prove and test that the seed is good sugar-beet seed, but have to rely in all good faith on the source of origin—to purchase seed purporting to produce sugar-beet of 20 to 24 per cent. sugar content, or even higher, whereas the ultimate result may be far below the recognized standard.

The factory retails the seed to its growers at cost price, and usually the price per pound is some 30 per cent. below the cost of mangold and turnip seed. Some farmers believe that factories reserve the right to supply the seed as it is a source of lucrative income, but I can assure you that in my experience the result is often a loss on the total transaction.

The price paid for the beet varies year by year according to different factors which govern the situation—such as the price of sugar, excise duty payable on the sugar, or subsidy obtained by the manufacturer.

From a commercial standpoint a factory firstly desires to purchase its raw material as cheaply as possible; and secondly, it requires in total the maximum tonnage it can deal with in the season delivered regularly, in order to ensure economic working costs. The price a factory can pay depends upon its manufacturing costs and the world's price of sugar, which controls the selling price of its finished article.

Therefore it is to the advantage of the grower, as well as the factory, to see that the beets are supplied regularly in accordance with the contract, and that the factory has sufficient beets for a full campaign.

In order that the factory can obtain a full crop they must see that the price they offer per ton is one that with an average yield will give the farmer a fair profit. The factory is, therefore, always endeavouring to make the crop profitable to the grower, and employs a large agricultural staff of expert advisers who are at the beck and call of the growers, free of charge.

I have just mentioned that regular deliveries are a great economic

asset to a factory, and before passing on to other subjects I should like to enlarge on this most important point, especially as this paper is called "What the Factory wants."

The manufacturing period is approximately from 1st October to 15th January, but varies a few weeks on either side of these opening and closing dates; and there is a certain period in each season during which the sugar-beet reaches its maximum sugar content—deliveries before and after will show a lower sugar content.

The delivery clause of the contract is framed so that a grower may deliver a part of his crop before it has attained its maximum sugar content, another part during the highest period, and the balance during the declining period.

The majority of growers I have had to deal with, in spite of having signed a contract agreeing to certain delivery conditions, make every endeavour to deliver their crops when it has its highest sugar content; consequently a factory is starved of its necessary supplies at the commencement and end of its season and is overwhelmed during the middle period.

I know farming operations are largely controlled by climatic conditions, but still there is a lot of room for improvement in this branch of the industry. Farmers must look ahead and make careful plans for regular delivery of their crops, and always have their lifting operations ahead of their delivery programme, so that in the event of unsuitable lifting conditions they can still continue to supply the factory regularly. In other words, they must not live day by day but preferably month by month.

Before I leave the delivery question there are three "factory don't wants" closely connected with this subject.

Firstly, badly topped beets are a serious handicap, for if the beets are placed in silos badly topped they quickly commence to grow again at the eyes or leaf buds which have not been removed on the field, and this growing sets up heating, and causes serious losses in sugar content and weight. Beets found in the tare sample which are incorrectly topped are properly topped and go to increase the tare; but the grower is paid nothing for these tops—though he has to pay carriage on the weight of tops—whereas, if retained on the farm they are a valuable stock food or manure.

Secondly, weeds, hedge trimmings, leaves and straw, etc., are a big difficulty to contend with, and although elaborate mechanical devices are to be found at most factories for dealing with these nuisances these devices are not perfect when dealing with hundreds and thousands of tons of beets per day.

These weeds, etc., quickly put the cutting mill knives out of action, for they bind themselves round the knives and so prevent the knives from slicing up the beets. Weeds do not offer a sufficiently firm structure for the knives to cut up as the beets do.

Sugar-beet has rightly been described as a magnificent cleaning crop, and so it is if the correct cultivations are carried out at the correct time, but unfortunately many farmers do not keep their land as clean as they should do, and by using beet lifters and ball-pointed beet forks they consign to the factory all their rubbish along with their beets, quite overlooking the fact that the factory is not the receptacle for their botanical collections.

Lastly, stones, harrow chains, and horseshoes, etc., cause frequent havoc and devastation in a factory's slicing department, for in a single season many tons of such geological and mineral specimens are delivered along with the beets. These three pests cause the loss of many precious hours of capacity during a season.

I will now return to the land and the production of the crop itself, and would again repeat that it is one of the factory's chief and foremost thoughts in England to induce and educate its growers into producing a greater yield per acre.

It may appear to you that no inducement should be necessary to encourage a farmer to produce more beets per acre, and that only education and teaching are required, but I assure you I know of many farmers in East Anglia who strongly resent being pressed to increase their production, contending that their present yield is quite satisfactory, and that the more concentrated and careful manipulations and manuring that we suggest are too much trouble to carry out.

As my own personal opinion I issue a solemn warning that unless the yield per acre is not on the average increased by some 2 to 3 tons per acre before the subsidy expires the industry as a national one is doomed.

The average yield per acre as calculated on a factory's total crop of, say, 15,000 to 20,000 acres is absurdly low, it should be 10 to 12 tons per acre; and this is not an impossible yield per acre, for each year there is a sufficient percentage of growers who attain and even exceed this yield.

I read recently of a very intensive and thorough campaign that was carried on in the States on this same important point of increased yield per acre, and I understand that in a single season the average yield was raised nearly 2 tons per acre.

From my experience I have found that the average farmer thinks far too much of the sugar content of the beet he is going to raise and not nearly enough of the tonnage of the sugar-beet per acre he is going to produce. A degree of sugar content under the existing contract is worth 2s. 6d. per ton over $15\frac{1}{2}$ per cent., whereas a ton of beet at $15\frac{1}{2}$ is 54s. On the average, the sugar content of the beets produced in England is highly satisfactory, and compares very favourably with—and in many cases exceeds—the sugar content of beets grown in Europe and the States. You will therefore perceive that it is the yield per acre which is the outstanding vital point in this promising new industry,

and it is one that factory promoters and agricultural experimental stations must co-operate together on, and leave no stone unturned to improve.

Within reasonable limits it is the number of beets produced or grown on a square yard or on an acre of land which governs the yield per acre.

Continental practices reduced to our measurements lay down that, theoretically, an acre of land should have a stand of 38,000 to 40,000 beets at harvest time—or 8 beets per square yard.

Eight beets per square yard necessitates either very close singling or narrow drilling. As I mentioned before, this theory has its practical limits, and from careful investigations it has been found that beets will not flourish and mature if left closer than about 8 in. in the row, so the limits of singling are restricted ; therefore the only economy left is in the distance apart of the rows or drills.

Beets drilled in rows 18 in. apart and cut out and singled 9 in. apart in the rows will give the grower 8 beets to the square yard—or 38,720 beets per acre—provided he has an absolutely full plant.

Now 8 beets to the square yard—or 38,720 beets to the acre—if each beet has an average weight of only 16 oz., will give a yield of 17 tons to the acre ; and similarly 6 and 4 beets per square yard will give 12 and $8\frac{1}{2}$ tons per acre respectively.

These figures are ideally theoretical, but they do, in my opinion, open up the way to obtain an increased yield per acre over and above that at present obtained. I have put the beets as weighing only 16 oz. each, whereas the average weight of a beet produced in East Anglia is about 20 oz. ; therefore, with 8 beets to the square yard, and each beet at harvest weighing 20 oz., there would be a yield per acre of over 21 tons.

Our trouble in East Anglia is that the farmers for generations have been accustomed to growing the wasteful and unprofitable mangold on 24 in. or even 27 in. balks, and singling them out from 12 to 15 in. apart, and if they were to endeavour to grow 8 sugar-beet to the square yard on 24 or 27 in. balks they would have to leave the beets about 6 to $6\frac{1}{2}$ in. apart—which is far too close and would restrict the growth.

This wide mangold drilling has become so firmly set in the masters' and labourers' minds that the suggestion they should drill on 16 to 18 flat work was received with horror and suspicion, and from the commencement this advice was prejudicial to sugar-beet growing, but I am glad to say that of recent years sugar-beet growers are gradually placing their rows closer.

Again, the singling and leaving the beet regularly in the row has presented many difficulties. I have seen many thousands of mangold acreages but I can never recollect seeing a really full plant of mangolds, the best has been about 70 per cent. Farmers take a pride in growing

great bulky watery mangolds sooner than a number of smaller good-quality roots.

During the summer I visit many of our growers, and I am afraid I frequently cause disappointment when I am taken on to a field and the owner with pride points out a big 4 or 6 lb. sugar-beet, sitting in a big bare patch of land like an oasis in a desert, and asks if I do not think he has a record crop of 12 to 15 tons and I have to disagree with him, and put his yield down at 7 to 8 tons. Two or three beets, weighing from 1 to 1¼ lb. each, will very soon weigh far more than a few bigger brothers.

Again, the average grower is very nervous at growing his beet on the recommended 16 to 18 in. work, contending he cannot use his horse-hoes at this distance, but I am confident he can do so if he will use the right kind of horse driven by an intelligent team-man.

The ordinary root horse-hoe found on the average farm is a clumsy and difficult implement to control, but modern sugar-beet hoes will do splendid work on 16 to 18 in. work and will clean the land admirably and at the same time leave the plant intact. To ensure satisfactory horse-hoeing on 16 to 18 in. work, great care must be taken when drilling to see that the drills are carefully and accurately joined and that they are straight. I have in mind a concrete example on a large scale supporting this narrow-drilling theory. For the past two years endeavours have been made to establish beet-growing in the West Country, and the crops that have been grown on land that is not materially better than that used for beet in East Anglia have, as far as I can ascertain, averaged several tons per acre more than they do in Norfolk; and I am quite confident that this better yield is mainly due to the fact that these West Country farmers are accustomed to drill their ordinary mangolds on 16 to 18 in. flat work, therefore the factory's advice to do their sugar-beet in the same way has presented no difficulties.

I hope if I have not convinced the present company on this subject that I have started a train of thought, and that the ultimate result will be fruitful.

It is comparatively easy on paper to prove that it is the number of beets on an acre that gives the yield, but it is a very different matter to get the desired number in practice on the farm. Let us first start with the seed. The majority of mangold growers use 7 lb. per acre, or less, which, in my opinion, accounts for their 70 per cent. stand; but experienced sugar-beet growers always use 15 to 20 lb. per acre according to the season, and not because sugar-beet seed germinates badly or that the seed supplied is of poor germination. They look upon a good heavy seeding as the foundation of the crop, and unless the foundation is good the building will not be a success. A few extra pounds of seed at 6d. to 7d. per lb. is money well spent, and is as good as a life insurance policy. If the grower does not get a good plant in the first case it is a

heartless, uphill battle throughout the growing season, ending with a poor return.

I meet opposition and objections on all sides on this question, and am quoted instances of good crops produced on 7 to 8 lb. of seed. I quite admit, under favourable conditions of weather, 7 to 8 lb. of good seed per acre will give a full plant, but it is the adverse conditions you require to protect yourself against; the conditions may be admirable at the time of drilling, but may be quickly followed in our variable climate by many weeks of cold wet weather. Further, if you commence with only a bare full plant you are going to lose a lot of plants in hoeing, or by birds and pests before the crop is ready to harvest.

Some farmers believe that as the factory purchases and supplies the seed they are making money out of it, and therefore wish to encourage the liberal use; or that the seed is poor and therefore a lot must be used to produce the desired result. I have already mentioned that the factory is most careful about the quality of its seed, and the grower himself is protected by the Seeds Act of 1922.

Next to liberal seeding comes the correct preparation of the seed bed. Like other root crops, sugar-beet requires a good firm fine seed bed to produce the best results, and particular attention should be paid to the rolling.

The poor stand of sugar-beet which is obtained by a great many growers is due in many cases to insufficient rolling before and after drilling. I have known growers who have been at great pains and expense to prepare a beautiful mould and have not obtained a good germination, and in my opinion it is due to the fact that the seed has been buried too deep, which can be most easily done on a loose seed bed; and also, the seed has not been firmly surrounded by soil and so has germinated slowly. The seed must not be buried too deep, one inch is ample—better be shallower than deeper than an inch; many crops would produce better plants if seed were only just covered and rolled in afterwards. I have investigated many cases of supposed bad germination of the contended poor seed supplied by the factory, and in almost all such cases a good plant can be discovered on the headlands and on the sides of the furrows, with a few stragglers in the centre of the field, which clearly proves that where the soil was firmer—such as on the headlands—the seed could not so easily be buried too deep, and the surrounding soil was afterwards more firmly rolled; for the turning of the harrows, drill and roller on the headland all tend to make this part of the field harder than the centre.

Now we come to the drill itself and the manipulation of the drill—a most important part of the culture of sugar-beet, and one that, I am sorry to say, in England, is too frequently sadly neglected.

If I were a farmer I would make a point of being present and would walk behind the drill myself while the seed was being drilled, and

then if I did not get a plant I would have chiefly myself to blame. I believe, though I am open to contradiction, that this most important work is left to the team-man and the foreman, and quite frequently the latter is absent.

In the first case it is no good trying to put on 15 to 20 lb. of seed when your drill is mechanically unable to pass this quantity of seed. I am not very *au fait* with different types of drills, but I am sure that with a little ingenuity and the assistance of the local blacksmith the majority of flat-work drills can be made to put on the desired quantity of seed, and so avoid the expense of purchasing a special sugar-beet drill. However the proper drill should always be purchased by a grower whose acreage exceeds two figures, and smaller growers should combine together and purchase the right implement, for the outlay will, I am confident, bring in a good return year by year.

It must not be imagined that even the best drill will solve the difficulty and produce a good plant, for all drills must be carefully attended and watched. The mind of a farm labourer drifting across the field behind a drill on a beautiful spring day is apt to turn to thoughts of love and the maiden he hopes to meet in the evening, or the glass of beer he will find a home for later on, and while his thoughts are thus straying the drill blocks up, or temporarily fails to deliver its correct quota of seed. Therefore it is imperative that the owner of the farm and the gentleman who has to meet his bank manager occasionally should be present himself from beginning to end of the drilling.

As far as I can discover, few farmers, except the smallholders, can spare the time on what appears to be so trivial a task, and when such important matters as markets and other similar social amenities have to be attended.

The perfect farmer, having prepared the right seed bed, drilled the full amount of seed correctly, and not spared the roller, has now only to pray for some suitable weather, and in ten to twenty days, according to the temperature and precipitation prevailing, he should see the first indications of a good plant.

The getting of a good plant in England is not easy, and the retaining of it is still harder, especially if the acreage be over-large for the farm, and the labour of indifferent quality.

The singling of the crop can make or spoil it even though a perfect stand may have been ready for the hoe. I have frequently heard it said that singling is a most difficult job to do properly, and cannot be undertaken by unskilled men, but I think a few moments' careful study of what really has to be done will demonstrate that patience and care are the only two attributes really required, and if the worker does not have these qualities they can be supplied by strict supervision.

It is truly painful in the spring to see the many splendid crops in the making ruined by either late singling or careless singling, and in many cases both. The average farm labourer is the best labourer in the world, but the worst supervised: he is left too much on his own, and consequently, like all human beings, is inclined at times to become slack and careless.

I know of cases where gangs of unemployed have been practically, as you might say, turned adrift into a sugar-beet field to single a crop after a few brief hours', or even minutes', tuition, and then left for a day or two alone, consequently with disastrous results. As in the case of drilling, the farmer who wants to get a good 12 to 14 ton yield must be present practically every hour of the day when singling is going on, and, though his time may be valuable, he will ultimately receive a good financial return for his trouble. Singling day in and day out must be a monotonous job for the labourer, and I consider farmers would be well advised to pay for this work at piecework rates, plus a bonus per ton on the ultimate yield, instructing his men that the full plant is going to produce the best bonus.

You have all no doubt heard of the German statistics on early singling, but as I consider these so important I will take the liberty of repeating:

						Tons per Acre
Beets singled at the correct time, having 3 to 4 leaves, yielded						15
,,	,,	1 week later	.	,,	,,	,,	$13\frac{1}{2}$
,,	,,	2 weeks later	.	,,	,,	,,	10
,,	,,	3 weeks later	.	,,	,,	,,	7

And if any of you desire confirmation you should communicate with Mr Amos, of the Cambridge University Farm, who, I believe, has carried out similar experiments with parallel results.

The last cultural job is to keep the horse- and hand-hoes going till the leaves meet in the rows and so put a stop to such work.

I am afraid I have spent an unduly long time on the cultural side of the sugar-beet crop, which may appear to you to be outside the title of my paper, but, as I said earlier, the factory wants to live, and to manufacture sugar at a profit, and to do this the farmers must increase the present yield.

I honestly believe, and am bold enough to say at this conference, that it is in the cultivating of the crop that the average farmer is making mistakes, and not so much in the manuring; and if large numbers of growers were to carry out the correct manual operations at the correct time, and use no manures, they would obtain an increased yield amounting to 1 to 2 tons per acre; but let me hasten to add that if they could combine also the correct manuring as well, then they might hope for, and even obtain, an increased yield of 4 to 6 tons per acre. I refer, of

course, to crops which at present yield 3 to 4 tons per acre only, but in higher yields the increase would not be so large. I hope you follow what I mean—the best manure applied liberally will not give a good crop if, in the first place, there is only a 40 to 60 per cent. stand.

MANURIAL EXPERIMENTS WITH SUGAR-BEET AT ROTHAMSTED AND WOBURN

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The sugar-beet is comparatively new to British husbandry, and there is very little information in our agricultural literature about its responses to manuring. Sir John Lawes grew it at Rothamsted as long ago as 1871-75, and a certain Mr Duncan had a factory at Lavenham in Suffolk from 1869-1875. The beets at that time apparently yielded well, for Lawes got up to 24 tons per acre on his beet plots, but the sugar percentages were very low—9 to 12 per cent.[1]

In 1898 a large series of experiments was carried out in England, Wales and Scotland, and reports from some forty-seven of these are available. This series was controlled by a special committee of the Central Chamber of Agriculture, and the results, which were extremely interesting, do not seem to have received the attention which they deserve. *The mean yield of topped beet at all the centres was* as high as 16·3 tons, and the average percentage of sugar was 14·48 per cent.[2]

In 1911 the Board of Agriculture arranged a series of trials, which were carried out at some seven centres up and down the country, in which sugar-beet was grown with the cultural and manurial treatment common to mangolds in the districts concerned. These trials were not accurate experiments in the modern sense and they had the misfortune to be carried through in a season remarkable for summer and autumn drought. Despite this, they gave ground for a general recommendation as to the treatment of the crop, which has been fully confirmed in much subsequent practice. The general result showed that sugar-beet could be grown fairly well where mangolds would grow, and with much the same treatment, and that the result to be expected in yield of beets delivered to the factory was about 40 per cent. of the weight of mangolds which a farmer could expect from the same land. Thus, land which would normally produce 24 tons of mangolds would yield 9·6 tons of sugar-beet per acre.

[1] *J.R.A.S.E.*, 1898, **9**, 344.

[2] *J.B.A.*, 1899-1900, **6**, 45.

The general principles of manuring as applied to our older crops and revealed by many years of patient research were seen to be applicable to sugar-beet; and, further, there was a great mass of accumulated data concerning the treatment of this crop to be found in Holland, Germany, and other Continental countries. Some experimental work of various kinds had been carried out since the war in East Anglia and in the Midlands, and it appeared that though points of cultivation and field organization were the most important things requiring consideration, yet there remained a need for really critical experiments on the manuring of the crop when grown under English conditions. The points of manuring presenting themselves most urgently to the growers were concerned with the use of nitrogen and potash. The need for the use of nitrogenous and potassic salts in the manuring of the crop was generally felt wherever the crop was grown, whilst the need for added phosphate did not seem to be so universal or so urgent. Nitrogen and potash are both costly commodities, and the economical use of them is a point of considerable financial importance to the large and increasing body of sugar-beet growers.

Sugar-beet is known to be a gross feeder. It takes from the soil greater amounts of nitrogen, phosphates and potash than any other common farm crop except the mangold. This is shown by the following figures taken from Schneidewind[1] which have been converted to British units. They are based on the average yields and composition of the crops grown at Lauchstädt, Germany, on a loam soil, over a number of years.

TABLE I

AMOUNTS OF "PLANT FOOD" REMOVED FROM THE SOIL BY AVERAGE YIELDS OF THE CROPS NAMED

POUNDS PER ACRE

Crop	*Nitrogen*	*Phosphoric Acid* (P_2O_5)	*Potash*
Winter Wheat . .	76·9	32·3	73·7
Winter Rye . . .	61·9	41·3	93·9
Winter Barley . .	62·2	34·6	76·9
Spring Barley . .	52·6	30·6	71·3
Oats	75·7	38·4	101·7
Potatoes . . .	101·3	33·2	148·0
Mangolds . . .	163·5	65·0	226·3
Sugar-Beet . . .	179·5	62·0	206·8

[1] Schneidewind, *Die Ernährung der Landwirtschaftlichen Kulturpflanzen* (Berlin, Parey), 1922.

The sugar-beet, however, possesses, by virtue of its extensive root system, the power of utilizing the reserves of plant food in the soil to a much greater extent than other common crops. This is illustrated by the following result taken from the same source as Table I.

TABLE II

AMOUNTS OF "PLANT FOOD" TAKEN FROM PERMANENTLY UNMANURED SOIL AT LAUCHSTÄDT, GERMANY, BY VARIOUS CROPS. AVERAGE OF 7 YEARS' RESULTS

POUNDS PER ACRE

Crop	*Nitrogen*	*Phosphoric Acid* (P_2O_5)	*Potash*
Spring Barley . .	36·3	20·3	32·2
Winter Wheat .	63·1	28·2	53·5
Potatoes . . .	65·6	18·7	54·3
Sugar Beet . . .	90·2	27·5	114·4

Continental practice on the manuring of sugar-beet crops is summarized in the report of a French commission of inquiry,[1] and in Schneidewind's well-known book,[2] whilst a recently published volume by Roemer of Halle[3] deals comprehensively with all phases of sugar-beet culture on the Continent. Broadly speaking, the results of Continental experience are as follows :—

Farmyard Manure.—The crop responds well to this manure, which, if properly used, is stated to result in a yield of 4 to 4½ tons per acre higher than that obtainable with artificials alone. Dressings of about 10 tons per acre are stated to be sufficient, no marked response being obtained by the use of larger amounts.

Green Manures.—These are extensively used in Germany, although on the type of soil usually devoted to beet they are not so effective as farmyard manure. Leguminous crops are used: either clovers of various types sown in the preceding corn crop, or beans, peas and tares, separately or mixed, as catch crops sown on the stubble.

Artificial Fertilizers.—These are used liberally, but all three classes—nitrogenous, phosphatic and potassic—are needed in much smaller amounts when used in conjunction with dung than when

[1] *Report* by Émile Saillard on the tours of a Sub-Commission of the French Technical Commission appointed to inquire into the Cultivation of Beetroot in Germany, Austria and Belgium. Privately published, 1910.

[2] Schneidewind, *loc. cit.*

[3] Roemer, *Die Zuckerrübe und ihre Kultur* (Berlin, Parey), 1927.

the latter is omitted. The most favoured nitrogenous fertilizer is nitrate of soda, though when heavy dressings of nitrogen are employed a part may be given before seeding as sulphate of ammonia. In recent years many experiments have been carried out with the newer forms of nitrogenous fertilizers, some of which appear to be suitable for this crop.

When farmyard manure is used, dressings of from 2 to 4 cwt. of nitrate of soda are recommended, which should be increased by a further 2 cwt. in the absence of dung. Part of the nitrate is usually applied as a top dressing, and provided this is not applied too late (*e.g.* not later than the latter part of June) no depression of sugar content occurs.

Superphosphate is recommended as the most suitable form of phosphatic fertilizer. With farmyard manure, about 2 cwt. per acre is considered sufficient, to be increased to 3 to 4 cwt. if only artificials or artificials and green manures are used. There appear to be no grounds for the belief formerly held that the use of phosphates increases the sugar content of the crop.

The sugar-beet has a high requirement for potash, but owing to the high content of this ingredient in farmyard manure relatively small dressings in the form of artificials are needed; in the case of soils containing good natural reserves of potash this constituent of the artificial dressing is sometimes unnecessary even in the absence of dung. Potash gives the best results on light soils and peat. Muriate of potash or 40 per cent. potash manure salts are recommended on heavier soils, whilst on light soils kainit or other low-grade salts are preferred; they sometimes give better results than the higher grades. Autumn application of potash is stated to be preferable. When used with the older varieties of beet, potash often caused a depression of sugar content, but with the improved varieties now in use the reverse is the case, increases up to 0·6 per cent. being recorded. When used with farmyard manure, dressings of 0-2 cwt. of 40 per cent. salts or 0-4 cwt. of kainit are recommended, but about double these amounts may be used in the absence of dung.

Lime.—Sugar-beet is rather sensitive to sourness, so that sufficient lime should always be used to render the soil neutral.

With regard to the manuring of sugar-beet under British conditions, the specific problems presenting themselves can be set out shortly as follows :—

Nitrogen—

(*a*) How far and in what forms can nitrogen be used economically to increase the yield of beets per acre?

(*b*) Does the use of extra nitrogen cause a lowering of sugar percentage in the beets?

(*c*) At what point, if at all, does the fall in the sugar content counteract the gain in yield obtained by use of extra nitrogen?

Potash—

(*d*) What effect do dressings of potash have upon yield in sugar-beet?

(*e*) What influence does potash exert upon the formation and storage of sugar in the roots?

Field experiments designed to attack these problems were started at Woburn in 1925 and were continued both there and at Rothamsted in 1926.

The design of these experiments and the lay-out of the plots followed the principle of the Latin square,[1] which enables much of the difficulty arising from heterogeneity of soil on an experimental area to be overcome in the statistical analysis of results. It does not eliminate the whole of the effects of soil heterogeneity, but it enables the error due to the remainder to be accurately estimated.

A good impression of this is afforded by the results of the Woburn experiments on the effects of nitrogenous manuring.

The plots were arranged as shown in the following diagram (Fig. 1):

3N	N	O	2N	C
2N	3N	N	C	O
N	2N	C	O	3N
O	C	2N	3N	N
C	O	3N	N	2N

O = No artificials.

C = Basal only (3 cwt. Superphosphate and 1½ cwt. Sulphate of Potash).

N = Basal + Sulphate of Ammonia.

2N = Basal + Sulphate of Ammonia + Single Nitrate of Soda.

3N = Basal + Sulphate of Ammonia + Double Nitrate of Soda

Fig. 1

A uniform dressing of farmyard manure at the rate of 12 tons per acre was applied over the whole area. The soil is a loam derived from the Lower Greensand.

The actual weights in pounds of topped but unwashed beet obtained from each plot of $\frac{1}{60}$ acre are shown in the diagram on the next page, in which the arrangement of the treatments is the same as in the plan above.

[1] R. A. Fisher, *J.M.A.*, 1926-27, **33**, 503.

	Actual Weight in Lb.					*Total*	*Mean*	
	624	507	505	689	645	2970	594·0	
	641	581	613	557	516	2908	581·6	
	605	539	559	485	647	2835	567·0	Standard error = 6·55 per cent.
	483	788	602	688	755	3316	663·2	
	481	526	617	666	932	3222	644·4	
Total	2834	2941	2896	3085	3495	15251	3050·2	
Mean	566	588·2	579·2	617	699	3050·2	610·04	General Mean

Fig. 2

The mean yields of washed beet per acre for each treatment are shown in the following Table :

TABLE III

SUGAR-BEET EXPERIMENT AT WOBURN, 1926. NITROGENOUS SERIES

Treatment per Acre — *Dung +*	*Average Yield per Acre*		*Increase in Average Yield with addition of Nitrogen*
	tons	cwt.	
O = No Manure . .	10	0	...
C = Basal (Phosphate and Potash) . . .	12	3	...
N = Basal and Sulphate of Ammonia, 1½ cwt. .	12	13	+ 10 cwt.
2N = As N + Nitrate of Soda, 2 cwt. . . .	13	13	+ 1 ton
3N = As N + Nitrate of Soda, 4 cwt. . . .	12	14	− 19 cwt. (Decrease)

2 times standard error = ± 1 ton 12 cwt.

The average yields taken by themselves (Table III., p. 30) would appear to indicate that the first and second doses of nitrogen have produced increases in yield of 10 cwt. and 1 ton per acre, and that the third dose has produced a decrease of nearly 1 ton. Statistical analysis[1] of the data in Fig. 2, however, shows that the standard error of the average plot yields is rather high—6·55 per cent. In terms of yield of washed beet per acre this standard error corresponds to 16 cwt. For the odds to be over 20 to 1 in favour of a difference in average crop yields being significant, that difference must exceed twice the standard error. If it does not exceed the standard error itself, then the odds in favour of its being significant are only 2 to 1. In this experiment the differences among the average yields from the plots receiving varying nitrogen treatments are of the order of magnitude that the standard error would indicate as being likely to occur from other causes. Hence, none of those differences can be ascribed to the nitrogenous manures.

The high standard error is caused by the marked variation in the yields from similarly treated replicate plots, which is evident from inspection of Fig. 2, in which are also shown the considerable variations in the mean plot weights per row or column, each of which contains 1 plot with each treatment. This variation may be due, in part at least, to acidity. Although it was not known that the soil on which the experiment was laid out was acid, soon after sowing the beet, patches of spurrey began to appear, and by the time of singling these were strongly developed. As is usually the case with the development of sourness, the distribution was very irregular, and may well have had a greater disturbing influence than soil heterogeneity of other kinds.

On this particular soil, therefore, the use of nitrogenous artificials, in addition to dung, has not produced in the 1926 season any significant increase in yield. The nitrogenous fertilizers produced no significant effect on sugar content, the values for treatments C, N, 2N and 3N all falling within the range of 16·2 to 16·6 per cent.

In the potash experiment a comparison of sulphate, muriate and 30 per cent. potash salts was made, at Woburn, at equal rates of potash equivalent to 1½ cwt. sulphate of potash per acre. The experiment was of the same general design as the nitrogen experiment—*i.e.* fivefold replication in a Latin square of 25 plots. It was situated in the same field and adjacent to the nitrogenous experiment. The results were as shown in Table IV., p. 32.

The accuracy of this experiment was high, the standard error working out to 1·94 per cent.

These results suggest that a response to potash is not always to be expected on Greensand soil in the presence of dung. Light soils derived from the Greensand are known to be exceptional with regard to potash supply, and instances of lack of response to potash on soils

[1] R. A. Fisher, *J.M.A.*, "Statistical Methods for Biological Workers" (Edinburgh, Oliver & Boyd, 1925), p. 229.

of this type are not uncommon with a variety of crops. On the other hand the contrast between the 30 per cent. salts and the higher grades is striking. The 30 per cent. salts have produced a significant increase in both yields of beet and percentage of sugar, so that the amount of sugar obtained per acre is 7 cwt. more with this manure than with muriate or sulphate of potash.

TABLE IV

SUGAR-BEET EXPERIMENT AT WOBURN, 1926. POTASH SERIES

Treatment per Acre	*Yield per Acre*		*Per cent. Sugar in Beet*		*Sugar per Acre (cwt.)*	
Dung 12 tons +	*Tons Cwt.*	*Increase in Yield with addition of Potassic Fertilizer*	*Total*	*Difference from Basal*	*Total*	*Difference from Basal*
O = No Manure .	10 2	...	17·0	...	34	...
C = Basal, 3 cwt. Superphosphate, 1½ cwt. Sulphate of Amm., 2 cwt. Nitrate of Soda .	11 4	...	16·6	...	37	...
S = Basal and Sulphate of Potash .	11 4	*nil*	16·3	−0·3	37	*nil*
M = Basal and Muriate of Potash .	11 4	*nil*	16·4	−0·2	37	*nil*
K = Basal and 30% Potash Salts .	12 1	17 cwt.	18·2	1·6	44	7 cwt.

2 times standard error (1·94 per cent.) = ± 8 cwt.

At Rothamsted a suitable opportunity occurred to carry out a small-scale experiment on the manuring of beet, in which the size of the nitrogenous dressing was purposely exaggerated to a point well outside practical considerations. This was intended to show something of the effects of nitrogen on the plant when applied in considerable excess of practical needs. The soil, which is a clay loam recently broken down from grass, had received in the previous year a heavy dressing of dung, a complete dressing of artificials, and about 5 tons of burnt lime to the acre. Nitrogen was applied at four different rates :

(1) 2 cwt. of sulphate of ammonia before drilling.
(2) „ + 4 cwt. of nitrate of soda in two top dressings.
(3) „ + 7 cwt. of nitrate of soda in four top dressings.
(4) „ + 10 cwt. of nitrate of soda on four top dressings.

A basal dressing of 3 cwt. of superphosphate and 2 cwt. of muriate of potash was applied all over the plots. Each treatment was in quadruplicate and the lay-out was in a Latin square. From the experimental point of view the result was eminently satisfactory, the standard error being reduced to the low figure of 1·73 per cent. for the roots and 2·06 per cent. for the tops.

The average yield results are as follows :

TABLE V

SUGAR-BEET EXPERIMENT AT ROTHAMSTED, 1926

Treatment per Acre	*Average Yield of Roots*		*Per cent. Sugar*	*Sugar Per Acre*	*Average Yield of Tops per Acre*	
Basal +	*Tons Cwt.*	*Difference from 2N*			*Tons Cwt.*	*Difference from 2N*
		tons cwt.		cwt.		tons cwt.
2N = 2 cwt. Sul. of Ammonia . .	15 17	...	18·0	57	24 0	...
6N = as 2N + 4 cwt. Nitrate of Soda	14 12	−1 5	17·4	51	25 6	1 6
9N = as 2N + 7 cwt. Nitrate of Soda	14 12	−1 5	16·8	49	26 0	2 0
12N = as 2N + 10 cwt. Nitrate of Soda	14 19	−0 18	17·2	51	25 13	1 13

Roots—2 times standard error = ± 10 cwt. *Tops*—2 times standard error = ± 1 ton.

Thus an excessive dressing of nitrogen appears to increase the amount of tops formed rather than the yield of roots. In the Woburn experiments the weight of tops was approximately equal to that of roots, but in this experiment for every 100 lb. of roots there were about 170 lb. of tops. This increase of leafy growth appears to be accompanied by a definite but small reduction in the sugar content.

It is obvious that these experiments are of a purely preliminary nature, and the results refer to only one season and only two types of soil. They are but the beginning of a series in which it may be possible to investigate the specific manurial requirements of the sugar-beet under British conditions of soil and climate.

EFFECTS OF CLIMATE ON THE CULTIVATION OF SUGAR-BEET

By I. J. SCHAPRINGER

I WILL first of all claim a few minutes of your time to deal with the parentage of that remarkable plant the sugar-beet.

The great-great-grandparent of sugar-beet is supposed to have grown wild somewhere on the Adriatic Coast and in Asia Minor for a considerable time before its sugar value was discovered. It then fell to the provinces of Saxony and Silesia, in Germany, to make use of its value as a sugar producer. The wild plant was not of much value without the help of science, but from the moment its potential value was known its future was assured, and it has grown up to be the sturdy parent of the present breeds of beet which are grown as far north as Sweden, in Europe, and in Japan and Manchuria, in Asia, and in Canada in the New World; while in the Southern Hemisphere, Australia has also produced it in commercial quantities.

In the early years of its infancy scientists were obsessed with the fear that beet could be grown only under certain climatic conditions. Each country that contemplated its cultivation on a commercial scale consulted its scientists as to the suitability of its climate, but in most cases it was left to the company promoter to commence operations without much scientific guidance. Therefore, the expression "beet climate" has to be deleted from the dictionary of the industry. It is even very difficult to define what might be called "the most suitable climate."

The beet tried on small experimental plots, and then on a large commercial scale, accommodated itself to local climatic conditions, whatever they happened to be.

There is no doubt that the cost of growing beet varies under different climatic conditions—for example, in a climate with a very short lifting period, with early and hard winter frosts, the cost of production is higher, owing to the necessity of storing the beet until the factory can use it, and to the consequent loss in sugar content.

A comparison of the conditions governing the delivery of the beet from the farm to the factory in this country with those prevailing in Canada are interesting. In England the lifting period is the same as the manufacturing period—which is about three months—while in Canada the whole operation must be completed within from four to five weeks.

The deciding factors as far as climate is concerned can be grouped under the following headings :

(*a*) Rainfall or humidity ;
(*b*) Temperature or heat ;
(*c*) Hours of daylight during the growing season ;
(*d*) Wind.

The above factors may have different effects in the same vicinity according to the varying qualities of the soil. A light, sandy soil has a different moisture-holding capacity than a heavy clay soil. The heat-conducting capacity of a light soil is different to the same capacity of a heavy soil ; as an example, it is only necessary to plant two rows of beet—one on a light soil and the other on a heavy soil. The beet will germinate much quicker on the light soil than on the heavy soil, because the light soil holds the heat in a way that the heavy soil does not. Even the colour of the soil is of importance in this matter, as the lighter the soil is in colour the less will it store the heat. A light soil of dark colour is the best for this purpose.

Endeavours to work out arithmetical formulæ to determine the relationship of humidity, heat, sunlight and wind, and their combined effect on the growth and sugar content of the beet, have not been successful, and in this respect the scientist has to leave the field to the practical farmer.

In spite of this, the enlightened beet farmer cannot afford to dispense with the meteorologist's advice and assistance, which have become of such great aid in other branches of farming. In the old days our forefathers were dependent on the shepherd for their weather forecasts, but to-day we have outgrown the shepherd and prefer to consult the instrument.

The rainfall in different parts of the globe varies from *nil* to several hundred inches per annum. For agriculture in the temperate zone it is more important that the farmer should know the distribution of the rainfall over the months of the year than the total for the year. About 60 per cent. of the sugar in the beet is composed from elements which the plant absorbs from water. There is a time in the life of all animals when they take to solid foods, but with plants this period is never reached. Every bit of nourishment they take either from the air or the soil must be dissolved in water. It is easier to realize the importance of moisture to the plant when we remember that from 95 to 99 per cent. of all moisture absorbed by plants at the roots is released again into the air in form of vapour.

The British farmer is fortunately placed in comparison with the beet grower on the dry plains of Central Europe. On these plains the sowing has to be done very early in the year so as to make use of the winter moisture which remains in the soil. The following month may be rainless, and it is not until the autumn that heavy rainfalls occur, which not only spoil the quality of the beet but also increase the

difficulties of lifting and hauling. The unexpectedly favourable results which have attended the industry in this country are due mainly to the even distribution of rain all the year round, combined with high humidity and low evaporation.

Every plant needs a certain amount of warmth for germination and growth.

An average temperature of about 59° F. prevails over the best districts of Great Britain from June to August inclusive. The corresponding average temperature for the beet districts of the United States for the same period is about 11° F. higher, yet in spite of the lower temperature prevailing in this country the sugar content of the beet is 1½ to 2 per cent. higher than in the States. Cool nights and moderately warm days in the latter part of summer and in the autumn are most favourable for the storage of the sugar in the roots.

In this country the vagaries of climate are well known. After a few days of warm, early spring weather, a spell of cold weather may set in. This causes bolters, or seed runners, which constitute not only a loss to the farmer but also to the manufacturer, as the bolters harden and resist knives. This is the reason that British farmers are advised not to drill the beet too early, but only after the cold spell is finished.

In this country beet never stops growing—that is, its active productive life is never absolutely checked. This is due to the evenness of the climate, which has really no extremes of temperature.

The beet can stand up to eight degrees of frost when lifted, and even more when underground. If the roots themselves freeze after they are lifted no great amount of harm will result, provided they remain frozen until they are used by the factory. But such low temperatures are the exception here in England. Owing to this fact the lifting period is considerably longer than in any other beet-growing country. This is an advantage which cannot be overestimated, and it is one of the causes of success.

Factories in this country are in a position to work their beet direct from the fields and so avoid the cost and loss of storing. In certain countries 60 days is the average working time of a factory, in countries like Italy, even less, owing to abnormal losses in storage, whereas in Great Britain 80 and even 100 days would be a safe figure. This means that with the same capital one can slice nearly double the quantity of beet that can be sliced in some other countries.

To come to the third of the deciding factors—daylight. Sunshine has always been considered to be the maker of the sugar in the beet, but this is not quite correct. Daylight, as distinct from sunshine, is the real maker of the sugar. Sunshine applied too liberally has, in fact, the opposite effect, and this has been proved in Southern European countries. The question of the exact manner in which light affects the sugar content has not been yet fully explained. Intense light within

certain limits favours leaf growth, while high light frequently tends to retard it. As daylight lasts considerably longer in the Northern Hemisphere, this gives the explanation of the high sugar content in Canada and the northern parts of the United States, as well as in this country. It remains for our scientists to discover the reason why daylight is more beneficial than sunshine.

I have now come to the factor of wind in the growth of beet. In certain countries which are cursed with hot winds in the spring, beet suffers through their drying effect. In England the strong winds are only able to affect light, sandy soil, where the seeds may be blown away, or the young plants may be damaged by the winds cutting off their roots the moment they show above ground.

Before closing, I would like to make a few remarks on the storage of beet in this country. This is the last factor with which the farmer has to deal, and it is important when beet has to be stored for any length of time.

The first thing to remember is, that beet should be put in storage when the temperature is just above freezing point. Secondly, that beet should contain its maximum moisture when it is put in storage, and the storage should be made under such conditions that the natural moisture may be conserved.

As the natural weather conditions of this country are very favourable to ideal storage conditions it is likely, if these rules are followed, that the loss of sugar content will be considerably less than in less fortunate countries.

PRACTICAL EXPERIENCE WITH SUGAR-BEET IN S.W. ENGLAND

By C. J. CLARK

Chiselborough

The cultivation of sugar-beet in the West of England was first undertaken on a large scale in 1925, and our experience with the crop is therefore new and brief. The result of the first year's operations was such as to encourage the existing growers to extend their acreage considerably and to attract a number of new growers. With the increased area under the crop a series of new problems presented themselves which can be grouped under separate heads but which in practice are closely related to each other and to the whole balance and economy of the husbandry of the districts concerned.

First of all, there is some uncertainty as to the future of the industry and its position in the world market when it is no longer subsidized

by the State. There is much good land now under grass which could be broken up to grow excellent crops of sugar-beet, but such breaking up involves the use of some sort of arable rotation on the land, and comparatively few of the crops which are commonly used in the other shifts have much financial attraction at the present time. It follows that the cautious farmer must be very well assured of the lasting benefit he will get from his sugar-beet before he sets about to disturb established grassland.

Secondly, there is the very important matter of an efficient labour supply. The low wages paid to arable workers have discouraged the best of the younger men from following the plough.

Also in rural areas the question of housing for extra hands when they can be brought in from elsewhere is a very difficult one.

Farmers who may wish to increase their acreage of sugar-beet are brought face to face with a real difficulty in getting the extra hands necessary to deal with the crop. In many cases the area of beet grown has to be kept down to the limit of that which can be handled by the regular and existing staffs of the farms.

Men who can be obtained from the labour exchanges are, for the most part, factory workers, and have not the knowledge which would enable them to do the work properly.

Thirdly, there is no local tradition in the handling of the crop, and there is a great lack of practical and local information on such matters as suitable cultivations, width of rows and singling distances, correct manuring, and the economical use of tops and pulp.

The advantages of the crop were ably set forth for the farmers by the representatives of the Yeovil Sugar-Beet Factory Limited, but, despite this, the pressure of the difficulties already mentioned was very real, and a comparatively small acreage was contracted for with the factory.

In the result the interdependence of farm and factory in the production of sugar was clearly seen, and with a poor guarantee of acreage the whole factory building scheme was seriously delayed. This delay led to a further difficulty, for the beets of the 1926 crop had to be delivered to the Ipswich factory far away in Suffolk, causing there a considerable congestion and making it necessary for a number of growers to clamp a portion of their crop for delivery in January and February, after the usual manufacturing season.

An attempt to attack some of the outstanding problems of manuring and field treatment was made in a series of experiments centred on Bristol University and carried out in part under the auspices of the Somerset County Agricultural Advisory Committee. Two of these experiments—one concerned with the use of potash, nitrogen and phosphate, and the other with the width of drill rows—were carried out on our farm at Chiselborough, and I can quote the results for what they are worth.

It must be remembered that these figures are the result of single experiments, and they may differ both in sense and value from the results of the whole series when these have been collated by the central authority.

The manurial trial consisted of 8 plots each twelve rows wide and 135 yds. long. The rows were 18 in. apart and the beets were sown on the flat. The plot treatments were as follows :

Plot 1. Complete Manure, less 1½ cwt. muriate of potash per acre.
Plot 2 „ „ { 1 cwt. sulphate of ammonia per acre. 4 cwt. 30 per cent. superphosphate per acre. 1½ cwt. muriate of potash per acre.
Plot 3. „ „ less 2 cwt. superphosphate per acre.
Plot 4. Control, No Manure.
Plot 5. Complete Manure, plus an extra 1½ cwt. muriate of potash per acre.
Plot 6. „ „
Plot 7. „ „ with 6 cwt. kainit in place of 1½ cwt. muriate of potash.
Plot 8. „ „ with 1½ cwt. of sulphate of potash in place of 1½ cwt. muriate of potash.

Each of the plots was divided into three areas, called A, B and C, which received different amounts of nitrogen as top dressings.

Section A had 2 cwt. nitrate of soda per acre.
Section B had 1 cwt. nitrate of soda per acre.
Section C had no top dressing.

The results in yield per acre of washed beets and the percentage sugar contents are shown in the following Table :

Plot No.	*Yield*						*Sugar Content*		
	A		B		C		A	B	C
	tons	cwt.	tons	cwt.	tons	cwt.	per cent.	per cent.	per cent.
1	19	5	19	16	15	6	14·10	18·00	17·04
2	20	12	20	8	16	6	16·68	18·24	20·64
3	21	16	20	0	15	4	15·48	18·54	20·46
4	21	16	19	16	16	2	20·82	17·52	18·42
5	19	5	21	0	18	9	18·06	19·02	22·50
6	20	12	19	16	19	1	17·04	20·58	21·06
7	19	10	18	6	17	18	22·56	18·72	21·72
8	20	17	20	8	19	13	21·06	19·26	17·28

It will be observed that the level of yield was high throughout, even Section C of Plot 4 which received no manure at all producing as much as 16 tons 2 cwt. of washed beets per acre. With such a high level of yield the differences due to manuring are likely to be relatively small, and it is interesting to observe that the first top dressing of nitrogen produced a commercial increase in every case. The limits of experimental error in any set of single plots in a single season must necessarily be very wide, and small differences as between one plot and another cannot be regarded too seriously, but a definite trend over a large number of plots, and covering several different treatments, deserves more careful consideration.

If all the A sections are taken together as representing a plot receiving 2 cwt. nitrate of soda as top dressing, and a similar calculation and average is taken for the other two sections, the following result emerges :

Section	*Yield per Acre*		*Sugar Percentage*
	tons	cwt.	
A (2 cwt. N) . .	20	9	18·22
B (1 cwt. N) . .	19	19	18·73
C (no top dressing) .	17	6	19·89

It appears that the first cwt. of nitrate of soda has increased the gross yield by 2 tons 13 cwt., and that the second dose has caused a further increase of 10 cwt. This rise in yield has been accompanied by a definite fall of sugar percentage, and in order to correlate the two things, and to find out how far the gain in gross weight has been neutralized by loss of sugar content, it becomes necessary to reduce the calculation to terms of sugar per acre.

Section A yielded 75 cwt. of sugar per acre.
Section B ,, 75 ,, ,,
Section C ,, 69 ,, ,,

Taking the same figures and treating them from the point of view of gross cash return to the farm we get the following results :

Section A—Beet at £3, 0s. 9d. per ton = £62, 2s. per acre.
Section B ,, £3, 2s. 3d. ,, = £61, 18s. ,,
Section C ,, £3, 4s. 9d. ,, = £56, 10s. ,,

From these figures it would appear that in this experiment the first cwt. of nitrate of soda was a very profitable investment, but that the second one did not pay for itself.

The figures serve also to stress another point which is sometimes rather neglected. The heaviest yield brought the best return both of

sugar and cash, and the higher sugar percentage of the lighter crop was not sufficient to make up for the serious loss in gross weight.

The other experiment included five plots with the rows from 14 in. to 24 in. apart. Again all the yields were high, but there was a decided difference in favour of the narrow rows. The yields and cash values per acre were as follows :

Distance between Rows	*Yield per Acre*	*Cash Value at 60s. per ton*
in.	tons cwt.	£ s.
14	24 0	72 0
16	22 0	66 0
20	20 18	62 15
22	18 13	56 0
24	19 18	59 10

The results of this one season's experiments are interesting, and although they may not be wholly convincing in all the differences of manuring and treatment which they cover, they serve to form part of a far greater mass of evidence which is being collected in the West. Further, they serve to give some indication of the very satisfactory level of yield obtainable in the West Country under our normal farm conditions. As yet sugar-beet has no definite place in the rotations, and it has been taken generally either in place of mangolds or cereals.

The great advantage which it enjoys in that it is grown on contract for a price per ton, which is known in advance, coupled with the undoubted success of so many of this year's crops, lends very great support to the growing opinion that it should be used on a far larger scale in the West in the future. It seems that the crop might do much to preserve and to extend the arable area. Such an extension, bringing with it the greatly increased cash returns associated with heavy crops of beet, should benefit both the farmers and their workers to a considerable degree.

Beet, with the long harvesting period of three months, is very little damaged by wet conditions in autumn, and thus has another very great advantage over cereals, especially in the Western Counties, where the rainfall is high.

The success of the 1926 crop, and the eagerness with which the growers are seeking to extend their acreage, supports the conclusion that, given suitable land, the crop should present no insuperable difficulties to anyone who is used to growing root crops. The supply of labour for singling remains a critical point, and there is need for a great deal more information about the kinds and quantities of artificial manure to use.

If full advantage could be taken of the crop, and the area under it extended over suitable land, it should do more to put the farming industry on a sound basis than any other crop we have to select from.

EXPERIENCE WITH SUGAR-BEET IN THE MIDLAND COUNTIES

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Agricultural Organiser for Notts.

In 1924, when the Notts. Education Committee decided to draw up and carry out a scheme of manurial experiments on the sugar-beet crop along certain definite lines, it was understood that numerous experiments and field trials had been carried out in various parts of the country, which had, in a general way, demonstrated the value of manurial dressings. It was felt, however, that more evidence was required as to the economic returns obtained under varying classes of soil, bearing in mind its natural or acquired fertility, previous cropping and manurial treatment, and climatic conditions prevailing over a series of years. I should like to mention the fact that Mr N. Howard assisted in carrying out the whole of the work.

It was decided to arrange the experiments so that each series would aim to answer one definite question, such being in each case—

Series 1. The effect of nitrogenous top dressings.
Series 2. The effect of potash.
Series 3. The maximum profitable manuring.

The first two series have been running for three years, and Series 3 for two years, each being tried on two or three farms each year.

Although, as with all experiments on the manuring of sugar-beet, the results over the whole period would appear at first glance to be somewhat contradictory, as a matter of fact definite information has been obtained which will be of practical value. All the plots were duplicated to ensure reliability and to prevent errors due to any abnormal conditions.

Climatic Conditions.—Knowing the enormous influence of varying climatic conditions it was considered advisable to keep careful records of rainfall and temperature from seed-time to harvest.

Series 1—*Nitrogenous:*

Objects: To test the effect of a complete dressing of artificials (*a*) without a top dressing of nitrogen; (*b*) with one top dressing of nitrogen; (*c*) with two top dressings of nitrogen.

Scheme of manuring per acre :

Plot 1. Control (No Manure).

Plot 2. Complete Dressing { 1 cwt. sulphate of ammonia. / 4 cwt. 30 per cent. superphosphate. / 1½ cwt. muriate of potash.

Plot 3. As Plot 2, plus 1 cwt. nitrate of soda at singling time.

Plot 4. As Plot 3, plus a second top dressing of 1 cwt. nitrate of soda two or three weeks later.

1925 *Trials.*—Three centres were selected in the neighbourhood of Newark, the nature of the soil in each case being—

Centre 1. Light sand with gravel.
Centre 2. Good sandy loam in good "heart."
Centre 3. Light loam with gravel.

No farmyard manure was applied directly to the sugar-beet crops. At Centre 1 the adverse effect of drought was most pronounced.

TABLE I

SHOWING YIELD OF WASHED AND TOPPED BEET PER ACRE

Centre	*Plot 1 Control*		*Plot 2 Complete Dressing*		*Plot 3 Complete, + one Top Dressing of Nitrate of Soda*		*Plot 4 Complete, + two Top Dressings of Nitrate of Soda*	
	tons	cwt.	tons	cwt.	tons	cwt.	tons	cwt.
1	4	11	5	6	5	12	6	4
2	10	15	10	19	11	19	12	4
3	6	6	7	10	7	12	7	11

It will be seen that the application of one top dressing at singling gave very little increase of crop over the Complete Mixture Plot at Centres 1 and 3, whereas at Centre 2 there was an increase of one ton per acre, which gave a money return over the Control Plot of £1, 7s. 9d. per acre.

The second top dressing which was applied three weeks later gave a profitable increase at Centres 1 and 2, but a loss at Centre 3.

Nitrogenous Series, 1926.—This season was very favourable to the beet crop, and the effects of dressings of artificial manures were much more pronounced than in 1925. The judicious application of manures proved most beneficial, and 10 to 12 tons of washed and topped beets per acre were obtained on sand soil. Both centres were on the lighter types of soils and at neither was farmyard manure applied direct to the crop.

TABLE II

NITROGENOUS SERIES

Centre	*Plot*	*Yield per Acre Washed and Topped Beets*		*Per cent. Sugar*	*Duplicate Plots*		
					Yield per Acre Washed and Topped Beets		*Per cent. Sugar*
		tons	cwt.		tons	cwt.	
Ranby . .	1	9	5	19·3	9	0	19·5
	2	10	7	20·0	9	0	20·0
	3	11	13	20·1	10	15	20·0
	4	12	13	20·2	12	16	20·2
Warsop . .	1	9	6	19·1	9	6	19·1
	2	11	7	19·7	12	9	19·3
	3	9	3	18·3	11	15	19·2
	4	10	2	19·2	11	2	19·4

This Table shows the results obtained from the duplicate plots at both centres. A bare comparison of the figures from the two centres appears at first somewhat confusing, but when they are considered in conjunction with the previous cropping and manuring, definite conclusions may be drawn.

At Ranby no very pronounced increase was obtained by the application of a complete dressing (compare Plots 1 and 2), but the net returns over the No Manure Plots were very substantially increased when the top dressing was applied in addition to a complete dressing, and still further increased when a second top dressing was given.

Plots	*Average Yield Washed Beets per Acre*	*Value at 54s. per ton + 2s. 6d. per unit of Sugar over 15·5 per cent.*
	tons cwt.	£ s. d.
No. 4. Complete, + two Top Dressings.	12 14	41 16 9
No. 1. No Manure . .	9 2	29 1 8
Increase due to Manures .	3 12	12 15 1
Less Cost of Manures		3 11 0
		£9 4 1

Thus for an expenditure of £3, 11s. on manures there was a net gain of £9, 4s. 1d. per acre.

The same series at Warsop gave very different results. The application of a complete dressing, costing £2, 1s. per acre, gave an average increase of 2 tons 12 cwt. of washed beet per acre, worth £9, 1s. 7d., leaving a net increase of £7, 0s. 7d. due to the dressing. When, however, the top dressings were added, this substantial gain was lost owing to the increased cost of manures and a lower yield. At the Warsop Centre the land was heavily dressed with farmyard manure during the two previous years, and it is probable that the additional nitrogenous top dressings supplied an excess of nitrogen, which resulted in a too-luxurious growth of leaves, and a resulting lower yield owing to late ripening and the non-transference of food materials (with sugar) from the leaves to the root. In contrast with this, the Ranby Centre had received very little farmyard manure during previous years, and the same quantities of nitrogenous top dressings produced very profitable increases in crop.

Series 2—Potash:

These experiments were carried out in 1925 at the same centres alongside the nitrogenous plots and under similar conditions.

Scheme of Manuring per acre:

Plot 1. Control (No Manure).

Plot 2. Complete Dressing { 1 cwt. sulphate of ammonia. / 4 cwt. 30 per cent. superphosphate. / 1½ cwt. muriate of potash.

Plot 3. As Plot 2, less the potash.

Plot 4. As Plot 2, plus an extra 1½ cwt. muriate of potash.

TABLE III

SHOWING YIELD OF WASHED AND TOPPED BEET PER ACRE

Centre	*Plot* 1			*Plot* 2			*Plot* 3			*Plot* 4		
	tons	cwt.	qrs.	tons	cwt.	qrs.	tons	cwt.	qrs.	tons	cwt.	qrs.
1	4	12	3	5	8	3	4	15	0	6	1	1
2	10	15	0	10	19	2	10	12	0	11	10	3
3	6	6	2	7	13	0	6	2	0	7	4	2

A comparison of Plots 1, 2 and 3 shows the effect of a Complete Manure (Plot 2) over the Control (Plot 1); also over the No Potash (Plot 3). Practically no effect is produced by adding phosphate and nitrogen alone, but when potash is included a distinct increase is brought about at each centre. When the potash is doubled (Plot 4) an increase is shown at two of the centres, one of which is notably short of potash.

1926 *Trials.*—These experiments were carried out at the same centres alongside the Nitrogenous Series and under similar conditions of soil and previous treatment.

TABLE IV

POTASH SERIES

Centre	*Plot*	*Yield per Acre Washed and Topped Beet*		*Per cent. Sugar*	*Duplicate Plots*		
					Yield per Acre Washed and Topped Beet		*Per cent. Sugar*
		tons	cwt.		tons	cwt.	
Ranby . .	1	9	8	19·8	9	10	19·1
	2	8	15	19·6	8	19	19·6
	3	10	16	19·8	9	12	20·8
	4	9	17	19·9	9	2	20·6
Warsop . .	1	9	1	18·7	9	3	18·5
	2	10	16	19·1	11	6	19·0
	3	10	4	18·8	8	4	18·8
	4	12	15	19·7	11	7	18·5

Again, the two centres produced different results from similar manuring, and reference to the previous treatment of the land will show that at Ranby where substantial dressings of potash had been applied during the two previous years no benefit was obtained by a dressing of potash to the crop, and a comparison of yields with those obtained on the top-dressed plots in Series 1 on the same field will show that nitrogen was more urgently needed at this centre.

At Warsop the highest average net return was obtained on Plot 4—*i.e.*, that receiving a double dressing of potash—and reference to the Nitrogenous Series at the same centre shows that a definite increase was obtained by the introduction of potash in the complete mixture (Plot 2, Series 1), but the yield could not be further raised until the potash was increased as shown in Plot 4—Potash Series, as shown by the following Table :

Duplicate Plots	*Average Yield Washed Beet per Acre*	
	Tons	Cwt.
Potash Series 1. No manure	9	3
Potash Series 3. Super and nitrogen . . .	9	4
Potash Series 2. Potash, super and nitrogen .	11	4
Potash Series 4. Potash, super and nitrogen plus extra potash . . .	12	1

Series 3—Maximum Profitable Manuring:

This series was carried out at three centres in 1925 and at the Warsop Centre in 1926 (soil and previous treatment as before).

Objects: To ascertain the maximum dressing of fertilizers which may be economically used.

Scheme of Manuring per acre:

Plot 1. Control (No Manure).

Plot 2. Complete Dressing { 1 cwt. sulphate of ammonia. / 1½ cwt. muriate of potash. / 4 cwt. 30 per cent. superphosphate.

Plot 3. As Plot 2 plus 1 cwt. sulphate of ammonia and 1½ cwt. muriate of potash.

Plot 4. As Plot 2, plus 2 cwt. sulphate of ammonia and 3 cwt. muriate of potash.

Plot	*Yield Washed Beet per Acre*		*Per cent. Sugar*	*Duplicate Plots*		
				Yield Washed Beet per Acre		*Per cent. Sugar*
	tons	cwt.		tons	cwt.	
1	9	1	18·7	9	3	18·5
2	10	16	19·1	11	6	19·0
3	12	19	19·0	14	4	18·7
4	12	6	18·0	10	19	19·7

Plot 3 has given the highest yield in both cases and it appears from this and from previous years' results that dressings greater than that given to Plot 3 actually have a depressing effect on yield.

Conclusions

Nitrogen.—Under normal conditions top dressings of nitrogen, applied early, produce economic increased yields. If, however, the land is rich in organic matter, or is in a high state of fertility and has received heavy dressings of farmyard manure to the beet or previous crop, it is possible that an excess of nitrogen applied by top dressings may not only not increase the yield, but may be positively harmful.

Potash.—A shortage of potash may seriously limit the yield of sugar-beet. If potash has been supplied during the rotation, and the soil contains a sufficiency, any further dressing direct to the beet will not increase the yield and may even be detrimental.

General.—(1) There can be no hard-and-fast rule or standard dressing of manures for sugar-beet, and any scheme of manuring must be based on a knowledge of the soil, previous cropping and manuring.

(2) There is a fairly sharp limit to the quantity of artificials which may be applied with success, and beyond this yields may even be depressed.

(3) *Sugar Content.* — It may be stated with confidence that judicious manurial treatment with artificials is likely to promote quality, but that, on the whole, climate conditions, seed and soil play a more important rôle in this respect. An examination of all the Control—or No Manure—Plots will show that a slightly lower sugar return was obtained throughout than on the manurial plots. Excess of nitrogen is generally responsible for poor quality, but this may be negatived by a sufficiency of other necessary fertilizing constituents, or by favourable climatic conditions. A shortage of potash may also have a depressing effect on quality.

CULTIVATION TRIALS ON SUGAR-BEET. CENTRE—HADSOCK PRIORY

The object of these trials was to obtain definite information regarding the effects of cultivations on the yield of beet, and it is proposed to repeat them during a number of seasons. It should be clearly understood that no definite conclusions can be drawn from this one trial.

In the case of the number of hoeing trials, the object was to test the effect of soil movement, the killing of weeds being a secondary consideration.

Number of Horse-hoeings

Plot			
1	Two	—on June 2nd (before singling)	and June 22nd
2	Three	,, ,,	June 22nd and July 10th
3	Four	,, ,,	June 22nd and July 10th and 17th
4	Five	,, ,,	June 22nd and July 10th 17th and 23rd

Yields per Acre

Plot	*Tons*	*Cwt.*	*Qrs*	*Per cent. Sugar*
1	14	6	0	19·2
2	13	16	1	18·5
3	12	19	3	19·4
4	13	11	1	19·1

No increased crop resulted from hoeings in excess of two—*i.e.* one before singling and one after.

Width of Row Trials

Plot	*Width in In.*	*Tons*	*Cwt.*	*Qrs.*	*Per cent. Sugar*
1	16½	13	16	3	18·9
2	19	13	13	2	19·4
3	23	13	19	2	19·3

There was practically no difference in yields. It appears that the additional number of roots per acre does not necessarily mean a greater yield per acre. The difference in the size of the roots was very apparent when the plots were lifted and topped.

Plot	*Date of Singling*	*Tons*	*Cwt.*	*Qrs.*	*Per cent. Sugar*
1	June 7th	13	3	0	20·3
2	„ 11th	12	16	2	19·5
3	„ 16th	12	18	0	19·5
4	„ 21st	12	6	2	20·0

The singling on Plot 1 was carried out as early as the plants could be handled—*i.e.* when showing fourth leaf, and the results show an increase of nearly 1 ton over the plot singled last ; also the sugar content of the crop from this plot was the highest obtained at this centre.

It is too early to draw definite conclusions, further work being necessary.

THE DISCUSSION

Sir Frederick Keeble, in opening the discussion, said that he was greatly impressed, or depressed, by the smallness of the average yield of beet in this country.

He was convinced that this could be greatly bettered by more thorough cultivation of the soil.

The difference between farming and gardening was mainly one of soil conditions, and the difference between the yield of the same crops under the two conditions was enormous.

He thought that the first step to better yield should be cultivation, aimed at the making of good soil conditions, and that this might be followed by improved manuring.

He ascribed the very small increases of yield obtained with nitrogen manures in some of the experiments put before the conference to the operation of the law of limiting factors and not to any essential failure of artificial nitrogen as a manure for sugar-beet. Unless the other factors of growth were in balance, no plant could use the manure given to it to advantage.

He mentioned that in the near future large supplies of new types of nitrogenous and mixed manures would be available on the English market as the produce of our own industries ; and that these should prove interesting to sugar-beet growers and other intensive farmers.

Sir Frederick Hiam said that he had had satisfactory results with beet grown in rows 21 in. apart. He got these by using a 7 ft. drill equipped with four coulters.

Even with rows as far apart as this he had found it very necessary to use a light horse on the hoes as the big shire did a very great deal of damage in kicking up the plants in the rows.

He had found that wireworm was a serious pest to the crop when sown early and he had suffered considerable losses by birds, mostly crows and lapwings, which pulled up the young plants to get at the wireworms. He quite definitely delayed the sowings of his crop to avoid this trouble.

In the matter of manuring he used plenty of farmyard dung, and he had not found that it had had any such depressing effect upon the crop as had some of the heavier artificial dressings mentioned in the papers.

Mr W. F. Giles (Messrs Sutton & Sons), speaking of the production of sugar-beet seed, said that the plant had been grown experimentally by his firm for many years.

During the war, when the import of seed became impossible, Suttons had undertaken a home-grown supply for the Kelham Factory. It was possible to produce satisfactory seed in England in four years out of five, but unfortunately, owing to the high cost of labour here, the cost of production was too great for it to compete with a foreign article of equal, or perhaps greater, germination capacity. The future of sugar-beet seed production in England must depend simply on the cost of production.

In the matter of width of rows and heavy seeding, and their bearing on yield, he recalled an enormous crop of mangolds grown at 16 in. between the rows and with 16 lb. of seed per acre. These yielded 90 tons per acre, and the roots grew practically touching one another. The hoeing on this crop had been done with Planet Junior hoes, pushed by men and therefore without the use of horses. These hoes should be useful to sugar-beet growers using narrow rows.

Mr J. L. Luddington said that he had grown sugar-beet for a number of years and that now he was growing them on ridges with 24 in. between the rows. He found that he was getting a good crop of 12 tons per acre of washed beet and a sugar content of 16·2 per cent.

The final result of this in the way of net return was satisfactory, and the saving in cost of cleaning and hoeing was very considerable. He believed that ridge growing really served to reduce the cost of production per ton.

He had found in his experience that the factories treated the farmers well and he believed that it would be possible to secure the future of the industry as the subsidy dropped, by the production of a larger crop at a smaller cost to the farmer.

Mr A. W. Ling said that in the large series of sugar-beet experiments conducted last year from Bristol University over five Western

Counties, it had been found possible to alter the yield considerably by cultural methods and arrangements, but not the sugar content.

For instance, beet in rows 15 in. apart yielded 22 tons per acre, 18 in. apart, 20 tons per acre, 22 in. apart, 19 tons per acre, without any significant difference in sugar percentage.

This type of result was common among 300 separate experiments under consideration and gave point to the recommendation that the farmer should regard gross yield as the point of paramount importance in his beet crop.

An excess of nitrogen given to the crop either with the seed or as a top dressing was certain to lead to a large leafy growth without an equivalent increase in root. This leafiness was correlated with a delay in maturity which might have serious effects on the crop. As far as he could gather a dressing of 1½ cwt. per acre of sulphate of ammonia or calcium cyanamide before sowing, followed by a single top dressing of nitrate of soda at singling time, gave the best results in the West Country.

Speaking of potash manures, he said that on most light soils the applications of potash to the crop seemed to be profitable, but that on heavy soils—on the old red sandstone, and on the lias and other clays—the plots without potash had often given the best results, and increases of potash had often caused a progressive depression of crop. He thought that the sugar-beet as a plant was particularly well equipped for utilizing reserves of potash already in the soil.

He believed strongly in the necessity for singling at the earliest possible moment, and was curious to know more about the influence of variety on sugar content.

Col. G. H. Long said that during the last season the W. Suffolk Agricultural Committee had conducted a series of experiments with sugar-beet at some six centres in the county. Among other things they had tried different widths of rows (18 in. and 24 in.), but the yields had come out about the same. Many farmers in the district considered that beet grown on ridges 24 in. to 28 in. apart gave as good yields as those grown on the flat at 18 in., while the saving in cost in growing and cleaning them was considerable.

He had found that on thin-skinned land the number of fanged beet was very large unless the subsoil was well broken at the time of first ploughing. He used a subsoiling tine on his ploughs over the whole 100 acres which he intended to put under beet this next year.

He had found that sulphate of ammonia applied before drilling had tended to produce an improvement in the plant obtained. He suggested to Sir Frederick Hiam that the Suffolk horse was far better suited to work between relatively narrow rows than the shire.

Mr Shorten (Howard & Sons) said that his firm was extremely interested in the development of special and improved types of machinery

to help the growers. Recently they had turned out a new sugar-beet lifter, some special types of ploughs, and a hoe which would deal with four rows of beet at a time. He was sure that as improvements in production were outlined the implement makers would be doing all in their power to further them, and to help the growers in their task.

Mr T. Thomson said that some uncertainty existed in the West Midlands as to the date of sowing and its effect upon the number of bolters produced. In 1925 crops sown on 18th April had practically no bolters, while last year those sown as late as 10th May had many. If late sowing was insisted on as a precaution there was always a difficulty in getting the crop through to maturity.

He was anxious to know how far the beet suffered from exposure on the ridge, as there seemed to be a tendency among growers in Shropshire to turn to ridge cultivation.

Several farmers of his acquaintance who had been accustomed to vegetable growing and who were equipped with Planet Junior hoes had found benefit from the use of these tools in sugar-beet. He thought that there was a critical point of economic balance to be found between the use of horse and man labour in the working and handling of the crop.

It appeared to him that the facts adduced concerning the influence of daylight on sugar formation in the beet supported the opinion that every effort should be made to lengthen the growing season at the beginning.

Mr F. Rayns said that he had grown sugar-beet last season on the ridge and on the flat with equal distances between the rows on the farm of the Norfolk Agricultural Station. The yield had been practically equal in the two cases, with a very slight difference in sugar content (3 per cent.) in favour of the flat work. This difference was more than counterbalanced by the economy and ease of working on the ridge.

Many successful growers who had used the ridge system in Norfolk last year had earthed up the roots as a final operation, and this had been easy to do. He was convinced that in many circumstances the growing of sugar-beet on the ridge was a sound practical proposition.

Three years' work on the use of nitrogen with sugar-beet had brought him to much the same conclusions as those already mentioned. Increases of yield for the first dressings were soon followed by a check. This year he had applied the whole of the nitrogen by the time of singling and he had got response to a larger total dressings than when the applications had been spread out to a later date. He thought that there was a definite connexion between the use of nitrogen and the number of bolters in the crop.

Sir JOHN RUSSELL, in closing the discussion, first of all thanked the speakers and then stressed the twofold object of the Rothamsted Conferences. They were intended, he said, firstly to get the best information of all kinds bearing upon matters of immediate agricultural interest and to spread that information as widely as possible. Secondly, they were meant to obtain, for the Station, problems from the field that required scientific investigation.

Turning to the subject of discussion he said that the present position with regard to yield was obviously unsatisfactory. There seemed to be three lines of attack in the attempt to better it :

(1) Improvement of varieties to suit situations. Much had been done already, but there was hope of still further progress in this line.

(2) Improvement of cultivation and methods of spacing. In this department there was certainly room for very much more experience and experiment. Preparation of seed bed, depth of sowing, width of rows, ridge or flat—all were important matters requiring exact knowledge and probably local modification.

(3) Manuring might prove to be capable of producing most satisfactory results with sugar-beet as with other things, but great discrepancies were bound to occur until the foundations of cultivation for the crop had been established.

The matter of the time of application of nitrogen and its effect in producing an increase of top rather than root seemed to be bound up with the question of the utilization of the nitrogen by the plant. It was desirable to apply, at the right time, just that quantity of nitrogen which the plant could use in the production of the maximum amount of that type of growth which we might require. The extra nitrogen taken to produce unnecessary leaves in the beet was obviously ill applied even though it might be producing an increase in the total weight of the plant.

SUMMARY OF POINTS

BY C. HEIGHAM, M.A.

Rothamsted Experimental Station

Nature and Position of the Crop

(1) The growing of sugar-beet by a farmer and the making of sugar by a factory are to be regarded as parts of a single process of production. It is necessary for the continued success of either party that the two shall work together in close accord and sympathy.

(2) Sugar-beet being a comparatively new crop to this country there is no traditional method of growing it built up on generations of

field experience. There is much valuable information to be obtained from the Continent, but this must be tested under the local conditions of our own beet-growing districts before it can be used here with full advantage.

(3) The crop at present enjoys a degree of State protection which will decrease in future years. The period of subsidy is to be regarded as a time of education and experiment during which commercial machinery may be established and the growers may accumulate such knowledge and skill as will enable them to compete successfully in the open market.

(4) The yield of beets on many of our farms is unsatisfactory, and the average must be increased from $8\frac{1}{2}$ tons per acre to at least 10 or 11 tons per acre if the industry is to maintain itself in the future.

(5) Beet of high quality can be obtained in many parts of the country, and given good methods of production and adequate manufacturing facilities there is room for a greater development of the crop.

Factory Requirements

(6) In order to work to the best advantage the factory requires a regular supply of beets spread over the manufacturing period from October to the New Year. It is essential that growers should keep closely to the terms of their contract, as the factory organization depends on this.

(7) The factory obtains the best working results from beets containing a high percentage of sugar, and is seriously hindered by consignments which are not properly topped or which contain many bolters or much rubbish in the form of stones, weeds, etc.

(8) The overhead charges of the factory and its permanent staff of all kinds have to be spread over the number of working days in the year. The longer the period of full working the less per ton will these charges be. The English factories enjoy an advantage in that they have a working period of 100 days as compared with 40 to 80 days in some other countries.

Growers' Requirements

(9) Growers require an assured market for their product, and the fact that the price of sugar-beet is fixed in advance of the crop may be of great importance in stabilizing the finances of a farm in difficult times.

(10) At present much local information is needed on such matters as varieties of beet to grow, the best cultivations to use, and the most economical manuring.

(11) Short haulage and a cheap rate of transport to the factory are points of great importance in deciding the success of a crop. Bad roads,

long journeys to the station and long railway transport with high charges should be considered in detail before the contract with the factory is signed.

(12) An adequate labour supply in the spring and autumn—the critical seasons of the crop—is a matter of the first importance. The chances of obtaining the necessary labour when he wants it should be explored by the grower before he undertakes production of the crop.

(13) At the present time, and on the terms of existing contracts, high gross yield is more important to the grower than high sugar content if these two cannot be obtained together.

Each 1 per cent. of sugar below 15½ per cent. is worth 3s. 5d. per ton, while each 1 per cent. over that figure is paid for by the factory at 2s. 6d. per ton.

(14) The crop employs a good deal of costly labour, and therefore any labour-saving devices which can be applied in any stage of its treatment may have a very great influence in lowering the cost of production per ton.

The Requirements of the Crop

(15) The yield of the crop will depend very largely upon the number of plants grown to the square yard and the acre. Continental experience suggests that 8 plants per square yard is the optimum number. This is obtained by using narrow rows (14 in. to 16 in.), and singling to 8 in. apart. Many English crops have not more than 4 beets per square yard with a full plant.

(16) Whatever width of row or singling distance is used, it is desirable to obtain a "full plant" and to have as few gaps as possible. To obtain this with certainty a heavy seeding, 15 lb. to 20 lb. of seed per acre, is generally recommended.

(17) The seed bed should be fine and moist at the top, with the lower layers well broken to allow easy penetration of roots. The seed should be sown regularly and at a depth of not more than 1 in. The roller is a very important implement before, during and immediately after the seeding.

(18) Singling of the crop is an operation of critical importance. It should be done carefully and methodically as soon as the plants have four leaves. Each chosen individual should be left well planted at its regular distance from its neighbours.

(19) Hoeing by horse and hand should continue till the leaves of the plants meet in the rows. The exact number of times which the hoes should pass through the crop must depend on the soil, the season and the cleanliness of the field. The skill of the grower must be applied in deciding this in each case.

(20) Distance between rows and the use of flat or ridged seed beds must depend in some degree upon the soil, the local traditions in root

growing, and the grower's equipment of implements, horses and men. It appears that in general the narrower rows produce the best crop both in yield and sugar percentage, but there may be many exceptions to this rule.

(21) The question of subsoiling for the crop has to be considered on thin-skinned soils. A great deal of Continental experience goes to support the idea that on all but the deepest soils subsoiling should be a routine operation in the growing of sugar-beet. A number of English growers with experience are now using subsoiling tines on their ploughs.

(22) In general it may be said that problems of cultivation require to be attended to thoroughly before specific problems of manuring come to be considered. With sugar-beet in England at the present time there is great opportunity to increase the yield of the crop by an improvement of cultural methods.

(23) Good crops of sugar-beet have been grown in many districts with the manuring commonly used for the mangold crop. Sugar-beet being a more highly priced crop than the mangold may pay for a heavier application of fertilizers, but at present there is no special recommendation which suggests that its needs as a plant differ widely from the better-known root crop.

(24) There is need for properly co-ordinated experiments to be conducted throughout the beet-growing areas of the country to investigate the manurial needs of the crop under the very various conditions of soil and climate found within our borders.

(25) The climatic conditions of our country are particularly well suited to the successful production of sugar-beet. The long periods of daylight favour sugar production in the plant. The moderate average temperature during the growing period encourages steady and even growth in the field. The comparatively long period of harvest (100 days) brings a great advantage both to the farmer in his harvesting operations and to the factory in its business of slicing and sugar extraction. The absence of extremes of heat and cold makes it unlikely that the beets will be either severely checked in growth or badly damaged by frost before they can be delivered to the factory.

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CONTENTS

CONTINENTAL EXPERIENCE WITH THE GROWTH OF SUGAR-BEET

By J. M. VAN BOMMEL VAN VLOTEN

Expert to the Netherland Sugar Industry

When I received by intermediary of the Dutch Department of Agriculture your invitation to speak before this conference about some questions concerning sugar-beet culture, I at first hesitated to accept it. In the first place, I wish to state that it is very difficult for me to speak in a language which is not familiar to me, and in the second place, the circumstances in England are so different from those in Holland that I can hardly be expected to be an expert for your country.

However, the consideration that sugar-beet culture is rather a new one in England, and the fact that I greatly appreciated the honour conferred upon me by asking me to speak before this conference, made me decide to accept your invitation.

In a paper read by Mr Alfred Wood, Secretary to the British Sugar Society, to a meeting of the Farmers' Club, in March 1925, he explained how sugar-beet culture and sugar industry are dependent on each other. He has called the ten years during which the subsidy is given to the British sugar industry, an educational period for the farmers. It seems to me that he is quite right, and that during these ten years not only your practical farmers and your labourers must gain the experience by which the best results will be obtained, but that also your British agricultural scientists must prepare, by several researches, for the time when your sugar industry will have to face the competition of the production of other countries.

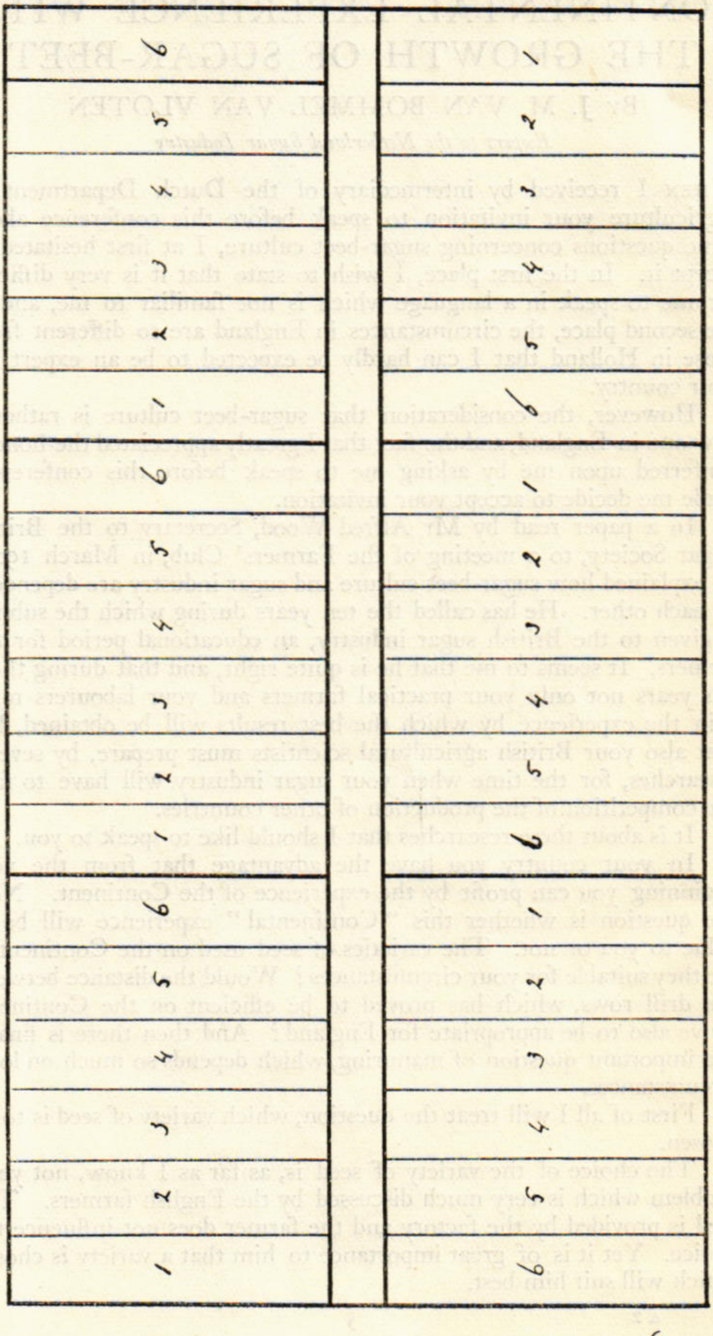
It is about these researches that I should like to speak to you.

In your country you have the advantage that from the very beginning you can profit by the experience of the Continent. Now the question is whether this "Continental" experience will be of value to you or not. The varieties of seed used on the Continent—are they suitable for your circumstances? Would the distance between the drill rows, which has proved to be efficient on the Continent, prove also to be appropriate for England? And then there is finally the important question of manuring, which depends so much on local circumstances.

First of all I will treat the question, which variety of seed is to be chosen.

The choice of the variety of seed is, as far as I know, not yet a problem which is very much discussed by the English farmers. The seed is provided by the factory and the farmer does not influence the choice. Yet it is of great importance to him that a variety is chosen which will suit him best.

SCHEME I



On the Continent, yearly, a great number of experiments are made by which different varieties are tested on yield and sugar content, for the choice of the variety can be made only if the results of careful and scientific experiments are known.

Therefore I will begin to tell you briefly how the experiments are made in Holland. A field is chosen in which the soil can be considered to be homogeneous. The number of varieties to be compared is about six. The field then is divided into 36 plots in the way as shown in Scheme I.

Those 36 plots are marked out on the field, each consisting of five rows of 100 beets. They must be rather small, otherwise the total of the experimental field will be too large, and the danger of the soil not being homogeneous will be greater. This is also the reason why no larger number of varieties can be compared.

The seed is sown by hand, the little hand-drills not being so suitable for this work.

By sowing the varieties of seed in this way they will all be distributed nicely over the field, and the influence of the soil is eliminated as much as possible. After sowing is done the most careful attention must be given to the crop to prevent sugar-beet being missing. Each missing root influences the results of the experiments.

In October the yield of each plot is weighed and the middle row is transported to a factory where the tare and sugar content are determined.

Of each variety about 600 beets are tested on sugar content. It is of great importance that the transport to the factory and the determination of the sugar content is done as quickly as possible, to avoid alterations on account of drying out or other causes.

The average weight and sugar content of the six plots of each variety is calculated, and conclusions drawn in the modern scientific way. If there is no good conformity between the results of the six plots of each variety it is advisable to consider the experiment to have been a failure.

It cannot be sufficiently emphasized that the experiments on sugar-beet culture must be made very carefully, for otherwise there is a great risk that wrong conclusions will be drawn.

The experimental commission of the Netherland sugar industry each year has, besides making experiments, about eight of these experimental fields in various parts of the country, all surveyed by two agricultural specialists who are solely in their service.

The results of the experiments have always shown that there is a great difference in quality between the various varieties of beet seed which can be bought. Several Continental producers of seed select their varieties in three directions, and by doing so they enable the factories to choose those varieties which are esteemed to be the most

efficient for the special circumstances under which their farmers are living.

These three types of varieties are frequently indicated by the letters E, N and Z.

E is a type giving a great yield with a low sugar content, whereas the Z type contains more sugar but yields a smaller weight. The type N (normal) stands, concerning sugar content as well as yield, between the types E and Z.

The question, which of these types is to be preferred, is much discussed. The answer depends not only on circumstances of soil and climate but also on the opinion of the farmers and the manufacturers. The opinion of the farmer and the manufacturer is often divided about this subject. The way in which the sugar-beets are paid for is closely connected with this problem. I shall deal with this question afterwards, when I shall be speaking about the subject: how in general the results of experiments must be judged.

An important matter which also can be solved by these experimental fields is the inclination of the different varieties to run to seed. The forming of bolters not only depends on conditions of growth but without a doubt is a hereditary property of the variety.

In Holland, for each variety the percentage of the roots which run to seed is determined, and I dare say that every year always the same varieties show the largest number of bolters.

It is my deliberate opinion that the producers of seed must be able to reduce the forming of bolters to a minimum.

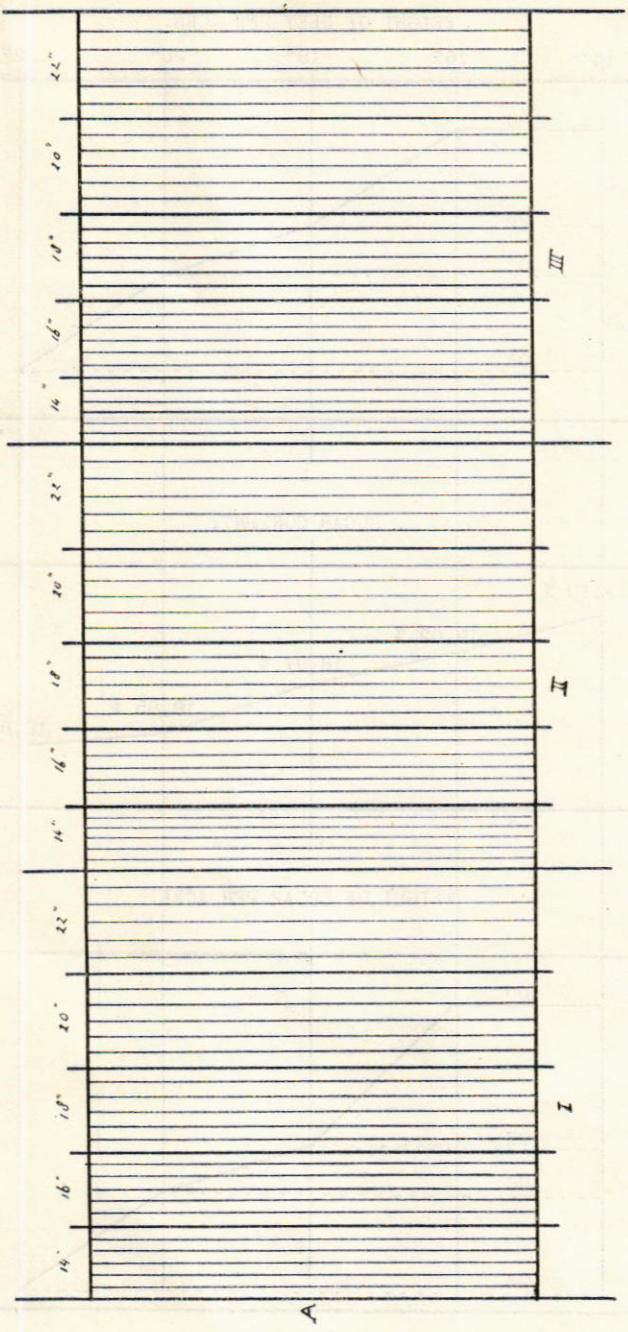
Out of the circumstances which influence the choice of the variety I shall only mention the soil. It is a matter of common knowledge that there are some soils which give a greater yield and a lower sugar content than others—I think the Fen district is a part of your country where such soils are found. I would advise not to choose for these soils the varieties of type E, because the beets, in all likelihood, would not be of high quality.

I shall now pass on to the second problem which I mentioned—the distance between the drill rows. Perhaps this problem is of peculiar importance for the English farmers, because I have the impression that drilling is too wide in England.

Wide drilling gives the advantage that horse-hoeing can be done easily and as long as possible. The number of rows is smaller ; bunching, singling and also the lifting and topping of the beets will require less labour ; on the other hand, however, the wider the drilling is done the lower the yield and the sugar content, and the larger the roots will be. But the increase of the weight of each root does not counterbalance the decrease of the number of beets.

In Holland we have drills covering about 6 ft. and fitted with five or six coulters, which means a distance between the rows of about 16 in. and 13 in.

SCHEME II



The distance of 16 in. is considered rather wide in Holland, but perhaps it is the most suitable one for your country. This must be ascertained by careful experiments.

I have no knowledge of experiments on this subject during the last years in Holland, but the Institute of the Czecho-Slovakian Sugar Industry published the results of many experiments in that country, which I suppose will interest you.

The experiments were made with the object of comparing the results to be obtained with a distance between the rows of 14, 16, 18, 20 and 22 in., and a distance between the plants *in* the rows of about 12 in.

The field was marked as shown in Scheme II. Beginning at A, at first seven rows, distanced 14 in., are marked out; then six rows follow, distanced 16 in.; then, again, six rows with a distance of 18 in., and so on. This method of marking is repeated three times.

After lifting, the five inner rows of each plot are weighed. By doing so the same number of roots of each plot is weighed, at least in theory. The yield per acre of each plot can be determined by conversion.

The average result of twenty-four of these experiments is shown in Table I and Scheme III.

TABLE I

Distance	*Weight of Beets*	*Sugar Content*	*Weight of Sugar*
14 in. . .	100[1]	19·10 per cent.	100[1]
16 ,, . .	100	29·02 ,,	100
18 ,, . .	98	18·97 ,,	97
20 ,, . .	97	18·85 ,,	96
22 ,, . .	95	18·83 ,,	94

The following conclusions can be drawn.

There is no great difference in the results of drilling at a distance of 14 or 16 in. As soon as the distance is larger, the weight of beets, the sugar content and the weight of sugar per acre are decreasing.

It is evident that the differences are not very large. The principal reason why I advised to keep small distances is that sugar-beet culture always gives the best results if an even stand or plant is obtained.

There are many reasons why the roots will grow thin and gappy: an uneven germination, a bad preparation of the soil, the wireworm and other pests are all dangers which always must be feared. The

[1] The weight of beets and the weight of sugar per areal unit, when the distance between the rows is 14 in., is supposed to be 100.

consequences of these dangers are so much the worse if the distance between the drill rows is wide.

The third question which I mentioned was the manuring of sugar-beet. As I already have said, the solution of this problem depends very much on local circumstances; and because Mr Page and Mr Heigham will speak about this question it seems to me preferable, now, to pass on to the problem of how the results of experiments in general must be judged.

The results of experiments are of consequence to the farmers as well as to the manufacturers. Both parties, however, look upon this matter in a different way. At first I shall explain how the farmer must judge the results of experiments, and then I shall speak about the standpoint of the manufacturer.

I take it that the price of 1 ton of roots, containing $15\frac{1}{2}$ per cent. of sugar, delivered to the factory sidings, is 54s., and that for each per cent. of sugar (or a fraction thereof) over $15\frac{1}{2}$ per cent. is added 2s. 6d. (or a fraction thereof).

The cost of production by the farmer, haulage and transport to the factory are supposed to be:

Cost of production per acre . .	£20 0 0
Cost of haulage per ton . .	0 4 0
Cost of transport per ton . .	0 5 0

I take it, further, that the results of the experiments are as follows:

Case I. 11 tons per acre, sugar content 18 per cent.
Case II. 11 tons 10 cwts. per acre, sugar content $17\frac{1}{2}$ per cent.
Case III. 12 tons per acre, sugar content 17 per cent.

The profit obtained by the farmer in each of these cases is shown in Table II.

TABLE II

Per Acre	I 11 *tons* 18%	II 11 *tons* 10 *cwt.* $17\frac{1}{2}$%	III 12 *tons* 17%
Weight of sugar	tons cwt. qr. lb. 1 19 2 11	tons cwt. qr. lb. 2 0 0 22	tons cwt. qr. lb. 2 0 2 34
Gross price .	£ s. d. 33 2 9	£ s. d. 33 18 6	£ s. d. 34 13 0
Cost of Production .	24 19 0	25 3 6	25 8 0
Profit .	8 3 9	8 15 0	9 5 0

It is clear that the farmer obtains the largest profit in the third case.

The yield per acre does not interest the manufacturer. He only takes into account the value of 1 ton of roots. In order to calculate the value of 1 ton of roots I take it that:

(1) The net return of sugar per cwt. is 42s.—inclusive subsidy and exclusive excise duty and all costs of selling and delivery;

(2) The return of the by-products (molasses, pulp, etc.) is 15s. per ton of roots;

(3) The waste of sugar (that is, the difference between the quantity of sugar in the beets and the quantity of refined sugar obtained in the factory) is $3\frac{1}{2}$ per cent.;

(4) The working expenses of the factory amount to £1 per ton.

The value of 1 ton of roots, then, can be calculated as shown in the following Table:

TABLE III

Per Ton	I 18%	II 17½%	III 17%
	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.
Weight of sugar . .	2 3 17	2 3 6	2 2 22
	£ s. d.	£ s. d.	£ s. d.
Return of sugar . .	6 1 10	5 17 7	5 13 5
Return of by-products .	0 15 0	0 15 0	0 15 0
Returns per ton . .	6 16 10	6 12 7	6 8 5
Working expenses and purchase price of beets .	4 0 3	3 19 0	3 17 9
Net return	2 16 7	2 13 7	2 10 8

First of all I must emphasize that this calculation is not absolutely right. The figures which I mention are based upon the suppositions which I made, and although I think that they don't deviate very much from the reality I must warn you not to consider them to be exact. I mentioned these figures only to be able to give an instance.

Moreover, the supposition that the waste of sugar and the working expenses are equal in all three cases is not right. They depend on the quality of the beets, which again depends on their purity. The prevalent opinion is that the sugar content and the purity of the juice which is to be obtained are proportional. Therefore it may be expected that the less sugar the beets contain the higher the working expenses and the waste of sugar per ton will be. Mr Fowler will be more able to treat of this question than I.

Anyhow we may say that for the manufacturer there is a difference in value between the beets of 18 per cent. and 17 per cent. of at least 5s. 11d. per ton in the circumstances which I mentioned; so the manufacturer will prefer Case I., whereas the farmer obtains the largest profit in Case III.

In looking upon this matter neither from the standpoint of the farmer nor from that of the manufacturer, but in a general way, obviously the results of experiments can be judged only by combining both calculations which I made. By doing so we consider sugar-beet culture and sugar industry as *one process of production, and I think that this is the only way in which the most efficient method of sugar production can be found.*

It would carry us too far to make these calculations, and, for the present, they are not of much importance for the English farmers, because neither the farmers nor the manufacturers combine sugar-beet culture and sugar industry in this way : they both look only for their own interests. In Holland, where the greater part of all sugar-beets are delivered to co-operative factories, the combined calculation is of more importance.

So the farmers in England, in judging the results of experiments, have to make the calculation which I showed you in Table II., and it is clear that it pays them best to grow beets giving a larger yield, with a smaller sugar content. It is a matter of fact that it is easier for the farmer to increase the weight of sugar per acre by growing these beets than by growing beets which contain more sugar.

For instance, by augmenting the quantity of nitrogenous manures the farmer is able to increase his crop. By doing so, however, the sugar content and the purity of the beets decrease, which is against the interest of the manufacturer. If the manufacturer wants the farmers to grow beets of high quality, with a good sugar content and purity, he must enable them to do so by paying for it.

When studying your sugar-beet contract it struck me that the farmer is not sufficiently paid for rich beets in proportion to beets of lower sugar content. For the first $15\frac{1}{2}$ per cent. of sugar 54s. is paid —that is, 3s. 5d. for each percentage—whereas for the percentages over $15\frac{1}{2}$ only 2s. 6d. is paid, notwithstanding that these percentages are of greater value to the manufacturer. It may be possible that the calculation of Table III. is not entirely right—the working expenses may be higher or lower, or there may be other reasons—but in any case this will not influence the *difference* which exists between the value of the various types of beets.

This calculation proves that the difference between the value of beets of 17 per cent. and 18 per cent. must be at least 8s. 5d.—of which the farmer receives only 2s. 6d.

It may seem that by making these remarks I have wandered from my subject, but I considered it worth while to make them because

I am convinced that only by a good method of payment of the sugar-beets can be brought together the divergent interests of the farmer and the manufacturer. Only if there is no large contrast between these interests can be found the most economical method of sugar production.

The last problem on which I should like to fix your attention is the question of the ripening of the beets.

Unripe beets contain less sugar, and their purity is low. The property of early and late ripening of the beets not only depends on conditions of growth, but also seems to be a hereditary property of the variety. At least, the producers of seed assert that the varieties of type E are late-ripening and that the Z types ripen early. I have no knowledge of experiments proving that this is right.

As to the conditions of growth, I will remark that large dressings of nitrogenous manures—and especially late top dressings—cause late ripening of the beets. It seems to me of interest to the farmers as well as to the manufacturers that, for the first deliveries to the factories of each campaign, beets are chosen of Z varieties, and that in any case no beets are chosen to which late top-dressings of nitrogenous manures have been applied.

I think that I ought now to finish, for the time which is reserved for my paper is over. I hope that what I have told you about experiments on sugar-beet culture and how to judge beets has interested you, and that it will contribute to the development of your sugar production.

I have still to make a request. If there are gentlemen who would like to ask me some questions I shall gladly try to answer them. But please speak as distinctly and slowly as possible, because it will be difficult for me to understand.

WHAT THE FACTORY WANTS AND HOW THE FARMER CAN SUPPLY IT

By T. G. FOWLER

Cantley Beet-Sugar Factory

The title of this paper was given to me by Sir John Russell, but I should have preferred to have designated it under a broader title.

You will readily apprehend that this subject can be discussed from two chief points of view. Firstly, the ideal mechanical and chemical aspect from the purely selfish manufacturing point of view of the manager of a sugar-beet factory; and secondly, from the commercial standpoint as it influences the purchasing, transporting and manufacturing of the sugar-beet into sugar, pulp and molasses, and the marketing of these finished products.

I do not propose to touch upon the first point, as I fear to frighten farmers away from producing sugar-beet altogether, and to deprive a large body of men from earning an honest livelihood who at present use their brains and labour in producing machinery, both mechanical and chemical, for combating the various difficulties which are to be met with in the farm and in the factory in the production of beet-sugar.

I shall endeavour to explain the commercial side of the English sugar-beet industry on a broad basis gleaned from the comparatively short experience I have gained at Cantley since 1920, and quite realize I am probably laying myself open to severe criticism from those who have enjoyed as many years experience in the industry as I have years of life.

Although I realize that this conference is to-day chiefly concerned with the production of sugar-beet on the farm, I think it will not be out of place to touch briefly on the marketing of the sugar-beet, as there are probably several farmers here to-day who have never grown sugar-beet, and before they commence to do so would, I imagine, naturally desire to know under what terms and conditions they can sell their sugar-beet crop.

Up to the present—and I imagine it will always remain so—sugar-beet growing is not undertaken by a farmer until he has first made a contract with a factory for a specified acreage for a period of one, two or three years.

Unlike the production of barley, wheat, potatoes and fruit, etc., there are few markets for sugar-beet, so unless a farmer enters into a contract with a factory before he drills his crop he has no market for his crop other than as a medium for converting his stock into meat. Similarly, a factory, in order that the necessary coal, limestone, bags, etc., can be purchased, and the factory plant put into order for the ensuing cutting season, must know, approximately at least, some six months before the crop is ready to harvest the quantity of beet it will have to deal with in a season.

Therefore the factory and the farmer frame a universal contract covering one or a series of years, and the term and conditions under which the beet will be delivered to and paid for by a certain factory. Such contracts are either offered by the factory subject to acceptance or rejection by the grower, or are arrived at after collective bargaining by the factory with a representative body such as the headquarters of the N.F.U.

I know only too well that the farmer all over the world enjoys a day out at a market, and a deal, and for many years I honestly believe many farmers did not grow sugar-beet, or as big an acreage as they were able to do, purely because the selling of sugar-beet was so dull—a few strokes of the pen and your signature and it was all over, and you were tied up for one or several years. A few adventurous farmers have experimented in growing without a contract, with the prospect

that they might find a factory willing to offer them a higher price during the cutting season, but I am afraid they have always met with bitter disappointment, as this practice, if generally adopted, would soon land the industry in difficulties.

The contract requires the farmer to grow a specified acreage of sugar-beet from seed supplied by the factory, and deliver all the crop from this acreage to the factory in a reasonably clean state and in a perfectly sound, healthy condition. The factory reserves the unqualified right to supply the seed, though quite prepared to permit the grower to choose one or any of the chosen varieties recommended and purchased by the factory.

It is vitally important to the factory and to the grower that only the best seed should be used, and if the choice of seed was left to the inexperienced farmer the result would invariably be disastrous, for many farmers would be induced by gullible and well-meaning salesmen —who themselves are not in a position to prove and test that the seed is good sugar-beet seed, but have to rely in all good faith on the source of origin—to purchase seed purporting to produce sugar-beet of 20 to 24 per cent. sugar content, or even higher, whereas the ultimate result may be far below the recognized standard.

The factory retails the seed to its growers at cost price, and usually the price per pound is some 30 per cent. below the cost of mangold and turnip seed. Some farmers believe that factories reserve the right to supply the seed as it is a source of lucrative income, but I can assure you that in my experience the result is often a loss on the total transaction.

The price paid for the beet varies year by year according to different factors which govern the situation—such as the price of sugar, excise duty payable on the sugar, or subsidy obtained by the manufacturer.

From a commercial standpoint a factory firstly desires to purchase its raw material as cheaply as possible; and secondly, it requires in total the maximum tonnage it can deal with in the season delivered regularly, in order to ensure economic working costs. The price a factory can pay depends upon its manufacturing costs and the world's price of sugar, which controls the selling price of its finished article.

Therefore it is to the advantage of the grower, as well as the factory, to see that the beets are supplied regularly in accordance with the contract, and that the factory has sufficient beets for a full campaign.

In order that the factory can obtain a full crop they must see that the price they offer per ton is one that with an average yield will give the farmer a fair profit. The factory is, therefore, always endeavouring to make the crop profitable to the grower, and employs a large agricultural staff of expert advisers who are at the beck and call of the growers, free of charge.

I have just mentioned that regular deliveries are a great economic

asset to a factory, and before passing on to other subjects I should like to enlarge on this most important point, especially as this paper is called "What the Factory wants."

The manufacturing period is approximately from 1st October to 15th January, but varies a few weeks on either side of these opening and closing dates; and there is a certain period in each season during which the sugar-beet reaches its maximum sugar content—deliveries before and after will show a lower sugar content.

The delivery clause of the contract is framed so that a grower may deliver a part of his crop before it has attained its maximum sugar content, another part during the highest period, and the balance during the declining period.

The majority of growers I have had to deal with, in spite of having signed a contract agreeing to certain delivery conditions, make every endeavour to deliver their crops when it has its highest sugar content; consequently a factory is starved of its necessary supplies at the commencement and end of its season and is overwhelmed during the middle period.

I know farming operations are largely controlled by climatic conditions, but still there is a lot of room for improvement in this branch of the industry. Farmers must look ahead and make careful plans for regular delivery of their crops, and always have their lifting operations ahead of their delivery programme, so that in the event of unsuitable lifting conditions they can still continue to supply the factory regularly. In other words, they must not live day by day but preferably month by month.

Before I leave the delivery question there are three "factory don't wants" closely connected with this subject.

Firstly, badly topped beets are a serious handicap, for if the beets are placed in silos badly topped they quickly commence to grow again at the eyes or leaf buds which have not been removed on the field, and this growing sets up heating, and causes serious losses in sugar content and weight. Beets found in the tare sample which are incorrectly topped are properly topped and go to increase the tare; but the grower is paid nothing for these tops—though he has to pay carriage on the weight of tops—whereas, if retained on the farm they are a valuable stock food or manure.

Secondly, weeds, hedge trimmings, leaves and straw, etc., are a big difficulty to contend with, and although elaborate mechanical devices are to be found at most factories for dealing with these nuisances these devices are not perfect when dealing with hundreds and thousands of tons of beets per day.

These weeds, etc., quickly put the cutting mill knives out of action, for they bind themselves round the knives and so prevent the knives from slicing up the beets. Weeds do not offer a sufficiently firm structure for the knives to cut up as the beets do.

Sugar-beet has rightly been described as a magnificent cleaning crop, and so it is if the correct cultivations are carried out at the correct time, but unfortunately many farmers do not keep their land as clean as they should do, and by using beet lifters and ball-pointed beet forks they consign to the factory all their rubbish along with their beets, quite overlooking the fact that the factory is not the receptacle for their botanical collections.

Lastly, stones, harrow chains, and horseshoes, etc., cause frequent havoc and devastation in a factory's slicing department, for in a single season many tons of such geological and mineral specimens are delivered along with the beets. These three pests cause the loss of many precious hours of capacity during a season.

I will now return to the land and the production of the crop itself, and would again repeat that it is one of the factory's chief and foremost thoughts in England to induce and educate its growers into producing a greater yield per acre.

It may appear to you that no inducement should be necessary to encourage a farmer to produce more beets per acre, and that only education and teaching are required, but I assure you I know of many farmers in East Anglia who strongly resent being pressed to increase their production, contending that their present yield is quite satisfactory, and that the more concentrated and careful manipulations and manuring that we suggest are too much trouble to carry out.

As my own personal opinion I issue a solemn warning that unless the yield per acre is not on the average increased by some 2 to 3 tons per acre before the subsidy expires the industry as a national one is doomed.

The average yield per acre as calculated on a factory's total crop of, say, 15,000 to 20,000 acres is absurdly low, it should be 10 to 12 tons per acre ; and this is not an impossible yield per acre, for each year there is a sufficient percentage of growers who attain and even exceed this yield.

I read recently of a very intensive and thorough campaign that was carried on in the States on this same important point of increased yield per acre, and I understand that in a single season the average yield was raised nearly 2 tons per acre.

From my experience I have found that the average farmer thinks far too much of the sugar content of the beet he is going to raise and not nearly enough of the tonnage of the sugar-beet per acre he is going to produce. A degree of sugar content under the existing contract is worth 2s. 6d. per ton over 15½ per cent., whereas a ton of beet at 15½ is 54s. On the average, the sugar content of the beets produced in England is highly satisfactory, and compares very favourably with—and in many cases exceeds—the sugar content of beets grown in Europe and the States. You will therefore perceive that it is the yield per acre which is the outstanding vital point in this promising new industry,

and it is one that factory promoters and agricultural experimental stations must co-operate together on, and leave no stone unturned to improve.

Within reasonable limits it is the number of beets produced or grown on a square yard or on an acre of land which governs the yield per acre.

Continental practices reduced to our measurements lay down that, theoretically, an acre of land should have a stand of 38,000 to 40,000 beets at harvest time—or 8 beets per square yard.

Eight beets per square yard necessitates either very close singling or narrow drilling. As I mentioned before, this theory has its practical limits, and from careful investigations it has been found that beets will not flourish and mature if left closer than about 8 in. in the row, so the limits of singling are restricted ; therefore the only economy left is in the distance apart of the rows or drills.

Beets drilled in rows 18 in. apart and cut out and singled 9 in. apart in the rows will give the grower 8 beets to the square yard—or 38,720 beets per acre—provided he has an absolutely full plant.

Now 8 beets to the square yard—or 38,720 beets to the acre—if each beet has an average weight of only 16 oz., will give a yield of 17 tons to the acre ; and similarly 6 and 4 beets per square yard will give 12 and $8\frac{1}{2}$ tons per acre respectively.

These figures are ideally theoretical, but they do, in my opinion, open up the way to obtain an increased yield per acre over and above that at present obtained. I have put the beets as weighing only 16 oz. each, whereas the average weight of a beet produced in East Anglia is about 20 oz. ; therefore, with 8 beets to the square yard, and each beet at harvest weighing 20 oz., there would be a yield per acre of over 21 tons.

Our trouble in East Anglia is that the farmers for generations have been accustomed to growing the wasteful and unprofitable mangold on 24 in. or even 27 in. balks, and singling them out from 12 to 15 in. apart, and if they were to endeavour to grow 8 sugar-beet to the square yard on 24 or 27 in. balks they would have to leave the beets about 6 to $6\frac{1}{2}$ in. apart—which is far too close and would restrict the growth.

This wide mangold drilling has become so firmly set in the masters' and labourers' minds that the suggestion they should drill on 16 to 18 flat work was received with horror and suspicion, and from the commencement this advice was prejudicial to sugar-beet growing, but I am glad to say that of recent years sugar-beet growers are gradually placing their rows closer.

Again, the singling and leaving the beet regularly in the row has presented many difficulties. I have seen many thousands of mangold acreages but I can never recollect seeing a really full plant of mangolds, the best has been about 70 per cent. Farmers take a pride in growing

great bulky watery mangolds sooner than a number of smaller good-quality roots.

During the summer I visit many of our growers, and I am afraid I frequently cause disappointment when I am taken on to a field and the owner with pride points out a big 4 or 6 lb. sugar-beet, sitting in a big bare patch of land like an oasis in a desert, and asks if I do not think he has a record crop of 12 to 15 tons and I have to disagree with him, and put his yield down at 7 to 8 tons. Two or three beets, weighing from 1 to 1¼ lb. each, will very soon weigh far more than a few bigger brothers.

Again, the average grower is very nervous at growing his beet on the recommended 16 to 18 in. work, contending he cannot use his horse-hoes at this distance, but I am confident he can do so if he will use the right kind of horse driven by an intelligent team-man.

The ordinary root horse-hoe found on the average farm is a clumsy and difficult implement to control, but modern sugar-beet hoes will do splendid work on 16 to 18 in. work and will clean the land admirably and at the same time leave the plant intact. To ensure satisfactory horse-hoeing on 16 to 18 in. work, great care must be taken when drilling to see that the drills are carefully and accurately joined and that they are straight. I have in mind a concrete example on a large scale supporting this narrow-drilling theory. For the past two years endeavours have been made to establish beet-growing in the West Country, and the crops that have been grown on land that is not materially better than that used for beet in East Anglia have, as far as I can ascertain, averaged several tons per acre more than they do in Norfolk; and I am quite confident that this better yield is mainly due to the fact that these West Country farmers are accustomed to drill their ordinary mangolds on 16 to 18 in. flat work, therefore the factory's advice to do their sugar-beet in the same way has presented no difficulties.

I hope if I have not convinced the present company on this subject that I have started a train of thought, and that the ultimate result will be fruitful.

It is comparatively easy on paper to prove that it is the number of beets on an acre that gives the yield, but it is a very different matter to get the desired number in practice on the farm. Let us first start with the seed. The majority of mangold growers use 7 lb. per acre, or less, which, in my opinion, accounts for their 70 per cent. stand; but experienced sugar-beet growers always use 15 to 20 lb. per acre according to the season, and not because sugar-beet seed germinates badly or that the seed supplied is of poor germination. They look upon a good heavy seeding as the foundation of the crop, and unless the foundation is good the building will not be a success. A few extra pounds of seed at 6d. to 7d. per lb. is money well spent, and is as good as a life insurance policy. If the grower does not get a good plant in the first case it is a

heartless, uphill battle throughout the growing season, ending with a poor return.

I meet opposition and objections on all sides on this question, and am quoted instances of good crops produced on 7 to 8 lb. of seed. I quite admit, under favourable conditions of weather, 7 to 8 lb. of good seed per acre will give a full plant, but it is the adverse conditions you require to protect yourself against ; the conditions may be admirable at the time of drilling, but may be quickly followed in our variable climate by many weeks of cold wet weather. Further, if you commence with only a bare full plant you are going to lose a lot of plants in hoeing, or by birds and pests before the crop is ready to harvest.

Some farmers believe that as the factory purchases and supplies the seed they are making money out of it, and therefore wish to encourage the liberal use ; or that the seed is poor and therefore a lot must be used to produce the desired result. I have already mentioned that the factory is most careful about the quality of its seed, and the grower himself is protected by the Seeds Act of 1922.

Next to liberal seeding comes the correct preparation of the seed bed. Like other root crops, sugar-beet requires a good firm fine seed bed to produce the best results, and particular attention should be paid to the rolling.

The poor stand of sugar-beet which is obtained by a great many growers is due in many cases to insufficient rolling before and after drilling. I have known growers who have been at great pains and expense to prepare a beautiful mould and have not obtained a good germination, and in my opinion it is due to the fact that the seed has been buried too deep, which can be most easily done on a loose seed bed ; and also, the seed has not been firmly surrounded by soil and so has germinated slowly. The seed must not be buried too deep, one inch is ample—better be shallower than deeper than an inch ; many crops would produce better plants if seed were only just covered and rolled in afterwards. I have investigated many cases of supposed bad germination of the contended poor seed supplied by the factory, and in almost all such cases a good plant can be discovered on the headlands and on the sides of the furrows, with a few stragglers in the centre of the field, which clearly proves that where the soil was firmer—such as on the headlands—the seed could not so easily be buried too deep, and the surrounding soil was afterwards more firmly rolled ; for the turning of the harrows, drill and roller on the headland all tend to make this part of the field harder than the centre.

Now we come to the drill itself and the manipulation of the drill—a most important part of the culture of sugar-beet, and one that, I am sorry to say, in England, is too frequently sadly neglected.

If I were a farmer I would make a point of being present and would walk behind the drill myself while the seed was being drilled, and

then if I did not get a plant I would have chiefly myself to blame. I believe, though I am open to contradiction, that this most important work is left to the team-man and the foreman, and quite frequently the latter is absent.

In the first case it is no good trying to put on 15 to 20 lb. of seed when your drill is mechanically unable to pass this quantity of seed. I am not very *au fait* with different types of drills, but I am sure that with a little ingenuity and the assistance of the local blacksmith the majority of flat-work drills can be made to put on the desired quantity of seed, and so avoid the expense of purchasing a special sugar-beet drill. However the proper drill should always be purchased by a grower whose acreage exceeds two figures, and smaller growers should combine together and purchase the right implement, for the outlay will, I am confident, bring in a good return year by year.

It must not be imagined that even the best drill will solve the difficulty and produce a good plant, for all drills must be carefully attended and watched. The mind of a farm labourer drifting across the field behind a drill on a beautiful spring day is apt to turn to thoughts of love and the maiden he hopes to meet in the evening, or the glass of beer he will find a home for later on, and while his thoughts are thus straying the drill blocks up, or temporarily fails to deliver its correct quota of seed. Therefore it is imperative that the owner of the farm and the gentleman who has to meet his bank manager occasionally should be present himself from beginning to end of the drilling.

As far as I can discover, few farmers, except the smallholders, can spare the time on what appears to be so trivial a task, and when such important matters as markets and other similar social amenities have to be attended.

The perfect farmer, having prepared the right seed bed, drilled the full amount of seed correctly, and not spared the roller, has now only to pray for some suitable weather, and in ten to twenty days, according to the temperature and precipitation prevailing, he should see the first indications of a good plant.

The getting of a good plant in England is not easy, and the retaining of it is still harder, especially if the acreage be over-large for the farm, and the labour of indifferent quality.

The singling of the crop can make or spoil it even though a perfect stand may have been ready for the hoe. I have frequently heard it said that singling is a most difficult job to do properly, and cannot be undertaken by unskilled men, but I think a few moments' careful study of what really has to be done will demonstrate that patience and care are the only two attributes really required, and if the worker does not have these qualities they can be supplied by strict supervision.

It is truly painful in the spring to see the many splendid crops in the making ruined by either late singling or careless singling, and in many cases both. The average farm labourer is the best labourer in the world, but the worst supervised: he is left too much on his own, and consequently, like all human beings, is inclined at times to become slack and careless.

I know of cases where gangs of unemployed have been practically, as you might say, turned adrift into a sugar-beet field to single a crop after a few brief hours', or even minutes', tuition, and then left for a day or two alone, consequently with disastrous results. As in the case of drilling, the farmer who wants to get a good 12 to 14 ton yield must be present practically every hour of the day when singling is going on, and, though his time may be valuable, he will ultimately receive a good financial return for his trouble. Singling day in and day out must be a monotonous job for the labourer, and I consider farmers would be well advised to pay for this work at piecework rates, plus a bonus per ton on the ultimate yield, instructing his men that the full plant is going to produce the best bonus.

You have all no doubt heard of the German statistics on early singling, but as I consider these so important I will take the liberty of repeating:

	Tons per Acre
Beets singled at the correct time, having 3 to 4 leaves, yielded	15
" " 1 week later . " " "	13½
" " 2 weeks later . " " "	10
" " 3 weeks later . " " "	7

And if any of you desire confirmation you should communicate with Mr Amos, of the Cambridge University Farm, who, I believe, has carried out similar experiments with parallel results.

The last cultural job is to keep the horse- and hand-hoes going till the leaves meet in the rows and so put a stop to such work.

I am afraid I have spent an unduly long time on the cultural side of the sugar-beet crop, which may appear to you to be outside the title of my paper, but, as I said earlier, the factory wants to live, and to manufacture sugar at a profit, and to do this the farmers must increase the present yield.

I honestly believe, and am bold enough to say at this conference, that it is in the cultivating of the crop that the average farmer is making mistakes, and not so much in the manuring; and if large numbers of growers were to carry out the correct manual operations at the correct time, and use no manures, they would obtain an increased yield amounting to 1 to 2 tons per acre; but let me hasten to add that if they could combine also the correct manuring as well, then they might hope for, and even obtain, an increased yield of 4 to 6 tons per acre. I refer, of

course, to crops which at present yield 3 to 4 tons per acre only, but in higher yields the increase would not be so large. I hope you follow what I mean—the best manure applied liberally will not give a good crop if, in the first place, there is only a 40 to 60 per cent. stand.

MANURIAL EXPERIMENTS WITH SUGAR-BEET AT ROTHAMSTED AND WOBURN

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The sugar-beet is comparatively new to British husbandry, and there is very little information in our agricultural literature about its responses to manuring. Sir John Lawes grew it at Rothamsted as long ago as 1871-75, and a certain Mr Duncan had a factory at Lavenham in Suffolk from 1869-1875. The beets at that time apparently yielded well, for Lawes got up to 24 tons per acre on his beet plots, but the sugar percentages were very low—9 to 12 per cent.[1]

In 1898 a large series of experiments was carried out in England, Wales and Scotland, and reports from some forty-seven of these are available. This series was controlled by a special committee of the Central Chamber of Agriculture, and the results, which were extremely interesting, do not seem to have received the attention which they deserve. The mean yield of topped beet at all the centres was as high as 16·3 tons, and the average percentage of sugar was 14·48 per cent.[2]

In 1911 the Board of Agriculture arranged a series of trials, which were carried out at some seven centres up and down the country, in which sugar-beet was grown with the cultural and manurial treatment common to mangolds in the districts concerned. These trials were not accurate experiments in the modern sense and they had the misfortune to be carried through in a season remarkable for summer and autumn drought. Despite this, they gave ground for a general recommendation as to the treatment of the crop, which has been fully confirmed in much subsequent practice. The general result showed that sugar-beet could be grown fairly well where mangolds would grow, and with much the same treatment, and that the result to be expected in yield of beets delivered to the factory was about 40 per cent. of the weight of mangolds which a farmer could expect from the same land. Thus, land which would normally produce 24 tons of mangolds would yield 9·6 tons of sugar-beet per acre.

[1] *J.R.A.S.E.*, 1898, **9**, 344. [2] *J.B.A.*, 1899-1900, **6**, 45.

The general principles of manuring as applied to our older crops and revealed by many years of patient research were seen to be applicable to sugar-beet; and, further, there was a great mass of accumulated data concerning the treatment of this crop to be found in Holland, Germany, and other Continental countries. Some experimental work of various kinds had been carried out since the war in East Anglia and in the Midlands, and it appeared that though points of cultivation and field organization were the most important things requiring consideration, yet there remained a need for really critical experiments on the manuring of the crop when grown under English conditions. The points of manuring presenting themselves most urgently to the growers were concerned with the use of nitrogen and potash. The need for the use of nitrogenous and potassic salts in the manuring of the crop was generally felt wherever the crop was grown, whilst the need for added phosphate did not seem to be so universal or so urgent. Nitrogen and potash are both costly commodities, and the economical use of them is a point of considerable financial importance to the large and increasing body of sugar-beet growers.

Sugar-beet is known to be a gross feeder. It takes from the soil greater amounts of nitrogen, phosphates and potash than any other common farm crop except the mangold. This is shown by the following figures taken from Schneidewind[1] which have been converted to British units. They are based on the average yields and composition of the crops grown at Lauchstädt, Germany, on a loam soil, over a number of years.

TABLE I

AMOUNTS OF "PLANT FOOD" REMOVED FROM THE SOIL BY AVERAGE YIELDS OF THE CROPS NAMED

POUNDS PER ACRE

Crop	*Nitrogen*	*Phosphoric Acid* (P_2O_5)	*Potash*
Winter Wheat	76·9	32·3	73·7
Winter Rye	61·9	41·3	93·9
Winter Barley	62·2	34·6	76·9
Spring Barley	52·6	30·6	71·3
Oats	75·7	38·4	101·7
Potatoes	101·3	33·2	148·0
Mangolds	163·5	65·0	226·3
Sugar-Beet	179·5	62·0	206·8

[1] Schneidewind, *Die Ernährung der Landwirtschaftlichen Kulturpflanzen* (Berlin, Parey), 1922.

The sugar-beet, however, possesses, by virtue of its extensive root system, the power of utilizing the reserves of plant food in the soil to a much greater extent than other common crops. This is illustrated by the following result taken from the same source as Table I.

TABLE II

AMOUNTS OF "PLANT FOOD" TAKEN FROM PERMANENTLY UNMANURED SOIL AT LAUCHSTÄDT, GERMANY, BY VARIOUS CROPS. AVERAGE OF 7 YEARS' RESULTS

POUNDS PER ACRE

Crop	*Nitrogen*	*Phosphoric Acid* (P_2O_5)	*Potash*
Spring Barley . .	36·3	20·3	32·2
Winter Wheat .	63·1	28·2	53·5
Potatoes . . .	65·6	18·7	54·3
Sugar Beet . . .	90·2	27·5	114·4

Continental practice on the manuring of sugar-beet crops is summarized in the report of a French commission of inquiry,[1] and in Schneidewind's well-known book,[2] whilst a recently published volume by Roemer of Halle[3] deals comprehensively with all phases of sugar-beet culture on the Continent. Broadly speaking, the results of Continental experience are as follows :—

Farmyard Manure.—The crop responds well to this manure, which, if properly used, is stated to result in a yield of 4 to 4½ tons per acre higher than that obtainable with artificials alone. Dressings of about 10 tons per acre are stated to be sufficient, no marked response being obtained by the use of larger amounts.

Green Manures.—These are extensively used in Germany, although on the type of soil usually devoted to beet they are not so effective as farmyard manure. Leguminous crops are used: either clovers of various types sown in the preceding corn crop, or beans, peas and tares, separately or mixed, as catch crops sown on the stubble.

Artificial Fertilizers.—These are used liberally, but all three classes—nitrogenous, phosphatic and potassic—are needed in much smaller amounts when used in conjunction with dung than when

[1] *Report* by Émile Saillard on the tours of a Sub-Commission of the French Technical Commission appointed to inquire into the Cultivation of Beetroot in Germany, Austria and Belgium. Privately published, 1910.

[2] Schneidewind, *loc. cit.*

[3] Roemer, *Die Zuckerrübe und ihre Kultur* (Berlin, Parey), 1927.

the latter is omitted. The most favoured nitrogenous fertilizer is nitrate of soda, though when heavy dressings of nitrogen are employed a part may be given before seeding as sulphate of ammonia. In recent years many experiments have been carried out with the newer forms of nitrogenous fertilizers, some of which appear to be suitable for this crop.

When farmyard manure is used, dressings of from 2 to 4 cwt. of nitrate of soda are recommended, which should be increased by a further 2 cwt. in the absence of dung. Part of the nitrate is usually applied as a top dressing, and provided this is not applied too late (*e.g.* not later than the latter part of June) no depression of sugar content occurs.

Superphosphate is recommended as the most suitable form of phosphatic fertilizer. With farmyard manure, about 2 cwt. per acre is considered sufficient, to be increased to 3 to 4 cwt. if only artificials or artificials and green manures are used. There appear to be no grounds for the belief formerly held that the use of phosphates increases the sugar content of the crop.

The sugar-beet has a high requirement for potash, but owing to the high content of this ingredient in farmyard manure relatively small dressings in the form of artificials are needed; in the case of soils containing good natural reserves of potash this constituent of the artificial dressing is sometimes unnecessary even in the absence of dung. Potash gives the best results on light soils and peat. Muriate of potash or 40 per cent. potash manure salts are recommended on heavier soils, whilst on light soils kainit or other low-grade salts are preferred; they sometimes give better results than the higher grades. Autumn application of potash is stated to be preferable. When used with the older varieties of beet, potash often caused a depression of sugar content, but with the improved varieties now in use the reverse is the case, increases up to 0·6 per cent. being recorded. When used with farmyard manure, dressings of 0-2 cwt. of 40 per cent. salts or 0-4 cwt. of kainit are recommended, but about double these amounts may be used in the absence of dung.

Lime.—Sugar-beet is rather sensitive to sourness, so that sufficient lime should always be used to render the soil neutral.

With regard to the manuring of sugar-beet under British conditions, the specific problems presenting themselves can be set out shortly as follows :—

Nitrogen—

(*a*) How far and in what forms can nitrogen be used economically to increase the yield of beets per acre?

(*b*) Does the use of extra nitrogen cause a lowering of sugar percentage in the beets?

(*c*) At what point, if at all, does the fall in the sugar content counteract the gain in yield obtained by use of extra nitrogen?

Potash—

(*d*) What effect do dressings of potash have upon yield in sugar-beet?

(*e*) What influence does potash exert upon the formation and storage of sugar in the roots?

Field experiments designed to attack these problems were started at Woburn in 1925 and were continued both there and at Rothamsted in 1926.

The design of these experiments and the lay-out of the plots followed the principle of the Latin square,[1] which enables much of the difficulty arising from heterogeneity of soil on an experimental area to be overcome in the statistical analysis of results. It does not eliminate the whole of the effects of soil heterogeneity, but it enables the error due to the remainder to be accurately estimated.

A good impression of this is afforded by the results of the Woburn experiments on the effects of nitrogenous manuring.

The plots were arranged as shown in the following diagram (Fig. 1):

3N	N	O	2N	C
2N	3N	N	C	O
N	2N	C	O	3N
O	C	2N	3N	N
C	O	3N	N	2N

O = No artificials.
C = Basal only (3 cwt. Superphosphate and $1\frac{1}{2}$ cwt. Sulphate of Potash).
N = Basal + Sulphate of Ammonia.
2N = Basal + Sulphate of Ammonia + Single Nitrate of Soda.
3N = Basal + Sulphate of Ammonia + Double Nitrate of Soda

Fig. 1

A uniform dressing of farmyard manure at the rate of 12 tons per acre was applied over the whole area. The soil is a loam derived from the Lower Greensand.

The actual weights in pounds of topped but unwashed beet obtained from each plot of $\frac{1}{60}$ acre are shown in the diagram on the next page, in which the arrangement of the treatments is the same as in the plan above.

[1] R. A. Fisher, *J.M.A.*, 1926-27, **33**, 503.

	Actual Weight in Lb.					*Total*	*Mean*	
	624	507	505	689	645	2970	594·0	
	641	581	613	557	516	2908	581·6	
	605	539	559	485	647	2835	567·0	Standard error = 6·55 per cent.
	483	788	602	688	755	3316	663·2	
	481	526	617	666	932	3222	644·4	
Total	2834	2941	2896	3085	3495	15251	3050·2	
Mean	566	588·2	579·2	617	699	3050·2	610·04	General Mean

Fig. 2

The mean yields of washed beet per acre for each treatment are shown in the following Table :

TABLE III

SUGAR-BEET EXPERIMENT AT WOBURN, 1926. NITROGENOUS SERIES

Treatment per Acre — *Dung +*	*Average Yield per Acre*		*Increase in Average Yield with addition of Nitrogen*
	tons	cwt.	
O = No Manure . .	10	0	...
C = Basal (Phosphate and Potash) . . .	12	3	...
N = Basal and Sulphate of Ammonia, 1½ cwt. .	12	13	+ 10 cwt.
2N = As N + Nitrate of Soda, 2 cwt. . . .	13	13	+ 1 ton
3N = As N + Nitrate of Soda, 4 cwt. . . .	12	14	− 19 cwt. (Decrease)

2 times standard error = ± 1 ton 12 cwt.

The average yields taken by themselves (Table III., p. 30) would appear to indicate that the first and second doses of nitrogen have produced increases in yield of 10 cwt. and 1 ton per acre, and that the third dose has produced a decrease of nearly 1 ton. Statistical analysis[1] of the data in Fig. 2, however, shows that the standard error of the average plot yields is rather high—6·55 per cent. In terms of yield of washed beet per acre this standard error corresponds to 16 cwt. For the odds to be over 20 to 1 in favour of a difference in average crop yields being significant, that difference must exceed twice the standard error. If it does not exceed the standard error itself, then the odds in favour of its being significant are only 2 to 1. In this experiment the differences among the average yields from the plots receiving varying nitrogen treatments are of the order of magnitude that the standard error would indicate as being likely to occur from other causes. Hence, none of those differences can be ascribed to the nitrogenous manures.

The high standard error is caused by the marked variation in the yields from similarly treated replicate plots, which is evident from inspection of Fig. 2, in which are also shown the considerable variations in the mean plot weights per row or column, each of which contains 1 plot with each treatment. This variation may be due, in part at least, to acidity. Although it was not known that the soil on which the experiment was laid out was acid, soon after sowing the beet, patches of spurrey began to appear, and by the time of singling these were strongly developed. As is usually the case with the development of sourness, the distribution was very irregular, and may well have had a greater disturbing influence than soil heterogeneity of other kinds.

On this particular soil, therefore, the use of nitrogenous artificials, in addition to dung, has not produced in the 1926 season any significant increase in yield. The nitrogenous fertilizers produced no significant effect on sugar content, the values for treatments C, N, 2N and 3N all falling within the range of 16·2 to 16·6 per cent.

In the potash experiment a comparison of sulphate, muriate and 30 per cent. potash salts was made, at Woburn, at equal rates of potash equivalent to 1½ cwt. sulphate of potash per acre. The experiment was of the same general design as the nitrogen experiment—*i.e.* fivefold replication in a Latin square of 25 plots. It was situated in the same field and adjacent to the nitrogenous experiment. The results were as shown in Table IV., p. 32.

The accuracy of this experiment was high, the standard error working out to 1·94 per cent.

These results suggest that a response to potash is not always to be expected on Greensand soil in the presence of dung. Light soils derived from the Greensand are known to be exceptional with regard to potash supply, and instances of lack of response to potash on soils

[1] R. A. Fisher, *J.M.A.*, "Statistical Methods for Biological Workers" (Edinburgh, Oliver & Boyd, 1925), p. 229.

of this type are not uncommon with a variety of crops. On the other hand the contrast between the 30 per cent. salts and the higher grades is striking. The 30 per cent. salts have produced a significant increase in both yields of beet and percentage of sugar, so that the amount of sugar obtained per acre is 7 cwt. more with this manure than with muriate or sulphate of potash.

TABLE IV

SUGAR-BEET EXPERIMENT AT WOBURN, 1926. POTASH SERIES

Treatment per Acre	*Yield per Acre*			*Per cent. Sugar in Beet*		*Sugar per Acre (cwt.)*	
Dung 12 tons +	*Tons*	*Cwt.*	*Increase in Yield with addition of Potassic Fertilizer*	*Total*	*Difference from Basal*	*Total*	*Difference from Basal*
O = No Manure .	10	2	...	17·0	...	34	...
C = Basal, 3 cwt. Superphosphate, 1½ cwt. Sulphate of Amm., 2 cwt. Nitrate of Soda .	11	4	...	16·6	...	37	...
S = Basal and Sulphate of Potash .	11	4	*nil*	16·3	−0·3	37	*nil*
M = Basal and Muriate of Potash .	11	4	*nil*	16·4	−0·2	37	*nil*
K = Basal and 30% Potash Salts .	12	1	17 cwt.	18·2	1·6	44	7 cwt.

2 times standard error (1·94 per cent.) = ± 8 cwt.

At Rothamsted a suitable opportunity occurred to carry out a small-scale experiment on the manuring of beet, in which the size of the nitrogenous dressing was purposely exaggerated to a point well outside practical considerations. This was intended to show something of the effects of nitrogen on the plant when applied in considerable excess of practical needs. The soil, which is a clay loam recently broken down from grass, had received in the previous year a heavy dressing of dung, a complete dressing of artificials, and about 5 tons of burnt lime to the acre. Nitrogen was applied at four different rates :

(1) 2 cwt. of sulphate of ammonia before drilling.
(2) „ + 4 cwt. of nitrate of soda in two top dressings.
(3) „ + 7 cwt. of nitrate of soda in four top dressings.
(4) „ + 10 cwt. of nitrate of soda on four top dressings.

A basal dressing of 3 cwt. of superphosphate and 2 cwt. of muriate of potash was applied all over the plots. Each treatment was in quadruplicate and the lay-out was in a Latin square. From the experimental point of view the result was eminently satisfactory, the standard error being reduced to the low figure of 1·73 per cent. for the roots and 2·06 per cent. for the tops.

The average yield results are as follows :

TABLE V

SUGAR-BEET EXPERIMENT AT ROTHAMSTED, 1926

Treatment per Acre	*Average Yield of Roots*		*Per cent. Sugar*	*Sugar Per Acre*	*Average Yield of Tops per Acre*	
Basal +	*Tons Cwt.*	*Difference from 2N*			*Tons Cwt.*	*Difference from 2N*
		tons cwt.		cwt.		tons cwt.
2N = 2 cwt. Sul. of Ammonia. .	15 17	...	18·0	57	24 0	...
6N = as 2N + 4 cwt. Nitrate of Soda	14 12	−1 5	17·4	51	25 6	1 6
9N = as 2N + 7 cwt. Nitrate of Soda	14 12	−1 5	16·8	49	26 0	2 0
12N = as 2N + 10 cwt. Nitrate of Soda	14 19	−0 18	17·2	51	25 13	1 13

Roots—2 times standard error = ± 10 cwt. *Tops*—2 times standard error = ± 1 ton.

Thus an excessive dressing of nitrogen appears to increase the amount of tops formed rather than the yield of roots. In the Woburn experiments the weight of tops was approximately equal to that of roots, but in this experiment for every 100 lb. of roots there were about 170 lb. of tops. This increase of leafy growth appears to be accompanied by a definite but small reduction in the sugar content.

It is obvious that these experiments are of a purely preliminary nature, and the results refer to only one season and only two types of soil. They are but the beginning of a series in which it may be possible to investigate the specific manurial requirements of the sugar-beet under British conditions of soil and climate.

EFFECTS OF CLIMATE ON THE CULTIVATION OF SUGAR-BEET

By I. J. SCHAPRINGER

I will first of all claim a few minutes of your time to deal with the parentage of that remarkable plant the sugar-beet.

The great-great-grandparent of sugar-beet is supposed to have grown wild somewhere on the Adriatic Coast and in Asia Minor for a considerable time before its sugar value was discovered. It then fell to the provinces of Saxony and Silesia, in Germany, to make use of its value as a sugar producer. The wild plant was not of much value without the help of science, but from the moment its potential value was known its future was assured, and it has grown up to be the sturdy parent of the present breeds of beet which are grown as far north as Sweden, in Europe, and in Japan and Manchuria, in Asia, and in Canada in the New World; while in the Southern Hemisphere, Australia has also produced it in commercial quantities.

In the early years of its infancy scientists were obsessed with the fear that beet could be grown only under certain climatic conditions. Each country that contemplated its cultivation on a commercial scale consulted its scientists as to the suitability of its climate, but in most cases it was left to the company promoter to commence operations without much scientific guidance. Therefore, the expression "beet climate" has to be deleted from the dictionary of the industry. It is even very difficult to define what might be called "the most suitable climate."

The beet tried on small experimental plots, and then on a large commercial scale, accommodated itself to local climatic conditions, whatever they happened to be.

There is no doubt that the cost of growing beet varies under different climatic conditions—for example, in a climate with a very short lifting period, with early and hard winter frosts, the cost of production is higher, owing to the necessity of storing the beet until the factory can use it, and to the consequent loss in sugar content.

A comparison of the conditions governing the delivery of the beet from the farm to the factory in this country with those prevailing in Canada are interesting. In England the lifting period is the same as the manufacturing period—which is about three months—while in Canada the whole operation must be completed within from four to five weeks.

The deciding factors as far as climate is concerned can be grouped under the following headings :

(*a*) Rainfall or humidity ;
(*b*) Temperature or heat ;
(*c*) Hours of daylight during the growing season ;
(*d*) Wind.

The above factors may have different effects in the same vicinity according to the varying qualities of the soil. A light, sandy soil has a different moisture-holding capacity than a heavy clay soil. The heat-conducting capacity of a light soil is different to the same capacity of a heavy soil ; as an example, it is only necessary to plant two rows of beet—one on a light soil and the other on a heavy soil. The beet will germinate much quicker on the light soil than on the heavy soil, because the light soil holds the heat in a way that the heavy soil does not. Even the colour of the soil is of importance in this matter, as the lighter the soil is in colour the less will it store the heat. A light soil of dark colour is the best for this purpose.

Endeavours to work out arithmetical formulæ to determine the relationship of humidity, heat, sunlight and wind, and their combined effect on the growth and sugar content of the beet, have not been successful, and in this respect the scientist has to leave the field to the practical farmer.

In spite of this, the enlightened beet farmer cannot afford to dispense with the meteorologist's advice and assistance, which have become of such great aid in other branches of farming. In the old days our forefathers were dependent on the shepherd for their weather forecasts, but to-day we have outgrown the shepherd and prefer to consult the instrument.

The rainfall in different parts of the globe varies from *nil* to several hundred inches per annum. For agriculture in the temperate zone it is more important that the farmer should know the distribution of the rainfall over the months of the year than the total for the year. About 60 per cent. of the sugar in the beet is composed from elements which the plant absorbs from water. There is a time in the life of all animals when they take to solid foods, but with plants this period is never reached. Every bit of nourishment they take either from the air or the soil must be dissolved in water. It is easier to realize the importance of moisture to the plant when we remember that from 95 to 99 per cent. of all moisture absorbed by plants at the roots is released again into the air in form of vapour.

The British farmer is fortunately placed in comparison with the beet grower on the dry plains of Central Europe. On these plains the sowing has to be done very early in the year so as to make use of the winter moisture which remains in the soil. The following month may be rainless, and it is not until the autumn that heavy rainfalls occur, which not only spoil the quality of the beet but also increase the

difficulties of lifting and hauling. The unexpectedly favourable results which have attended the industry in this country are due mainly to the even distribution of rain all the year round, combined with high humidity and low evaporation.

Every plant needs a certain amount of warmth for germination and growth.

An average temperature of about 59° F. prevails over the best districts of Great Britain from June to August inclusive. The corresponding average temperature for the beet districts of the United States for the same period is about 11° F. higher, yet in spite of the lower temperature prevailing in this country the sugar content of the beet is 1½ to 2 per cent. higher than in the States. Cool nights and moderately warm days in the latter part of summer and in the autumn are most favourable for the storage of the sugar in the roots.

In this country the vagaries of climate are well known. After a few days of warm, early spring weather, a spell of cold weather may set in. This causes bolters, or seed runners, which constitute not only a loss to the farmer but also to the manufacturer, as the bolters harden and resist knives. This is the reason that British farmers are advised not to drill the beet too early, but only after the cold spell is finished.

In this country beet never stops growing—that is, its active productive life is never absolutely checked. This is due to the evenness of the climate, which has really no extremes of temperature.

The beet can stand up to eight degrees of frost when lifted, and even more when underground. If the roots themselves freeze after they are lifted no great amount of harm will result, provided they remain frozen until they are used by the factory. But such low temperatures are the exception here in England. Owing to this fact the lifting period is considerably longer than in any other beet-growing country. This is an advantage which cannot be overestimated, and it is one of the causes of success.

Factories in this country are in a position to work their beet direct from the fields and so avoid the cost and loss of storing. In certain countries 60 days is the average working time of a factory, in countries like Italy, even less, owing to abnormal losses in storage, whereas in Great Britain 80 and even 100 days would be a safe figure. This means that with the same capital one can slice nearly double the quantity of beet that can be sliced in some other countries.

To come to the third of the deciding factors—daylight. Sunshine has always been considered to be the maker of the sugar in the beet, but this is not quite correct. Daylight, as distinct from sunshine, is the real maker of the sugar. Sunshine applied too liberally has, in fact, the opposite effect, and this has been proved in Southern European countries. The question of the exact manner in which light affects the sugar content has not been yet fully explained. Intense light within

certain limits favours leaf growth, while high light frequently tends to retard it. As daylight lasts considerably longer in the Northern Hemisphere, this gives the explanation of the high sugar content in Canada and the northern parts of the United States, as well as in this country. It remains for our scientists to discover the reason why daylight is more beneficial than sunshine.

I have now come to the factor of wind in the growth of beet. In certain countries which are cursed with hot winds in the spring, beet suffers through their drying effect. In England the strong winds are only able to affect light, sandy soil, where the seeds may be blown away, or the young plants may be damaged by the winds cutting off their roots the moment they show above ground.

Before closing, I would like to make a few remarks on the storage of beet in this country. This is the last factor with which the farmer has to deal, and it is important when beet has to be stored for any length of time.

The first thing to remember is, that beet should be put in storage when the temperature is just above freezing point. Secondly, that beet should contain its maximum moisture when it is put in storage, and the storage should be made under such conditions that the natural moisture may be conserved.

As the natural weather conditions of this country are very favourable to ideal storage conditions it is likely, if these rules are followed, that the loss of sugar content will be considerably less than in less fortunate countries.

PRACTICAL EXPERIENCE WITH SUGAR-BEET IN S.W. ENGLAND

By C. J. CLARK

Chiselborough

The cultivation of sugar-beet in the West of England was first undertaken on a large scale in 1925, and our experience with the crop is therefore new and brief. The result of the first year's operations was such as to encourage the existing growers to extend their acreage considerably and to attract a number of new growers. With the increased area under the crop a series of new problems presented themselves which can be grouped under separate heads but which in practice are closely related to each other and to the whole balance and economy of the husbandry of the districts concerned.

First of all, there is some uncertainty as to the future of the industry and its position in the world market when it is no longer subsidized

by the State. There is much good land now under grass which could be broken up to grow excellent crops of sugar-beet, but such breaking up involves the use of some sort of arable rotation on the land, and comparatively few of the crops which are commonly used in the other shifts have much financial attraction at the present time. It follows that the cautious farmer must be very well assured of the lasting benefit he will get from his sugar-beet before he sets about to disturb established grassland.

Secondly, there is the very important matter of an efficient labour supply. The low wages paid to arable workers have discouraged the best of the younger men from following the plough.

Also in rural areas the question of housing for extra hands when they can be brought in from elsewhere is a very difficult one.

Farmers who may wish to increase their acreage of sugar-beet are brought face to face with a real difficulty in getting the extra hands necessary to deal with the crop. In many cases the area of beet grown has to be kept down to the limit of that which can be handled by the regular and existing staffs of the farms.

Men who can be obtained from the labour exchanges are, for the most part, factory workers, and have not the knowledge which would enable them to do the work properly.

Thirdly, there is no local tradition in the handling of the crop, and there is a great lack of practical and local information on such matters as suitable cultivations, width of rows and singling distances, correct manuring, and the economical use of tops and pulp.

The advantages of the crop were ably set forth for the farmers by the representatives of the Yeovil Sugar-Beet Factory Limited, but, despite this, the pressure of the difficulties already mentioned was very real, and a comparatively small acreage was contracted for with the factory.

In the result the interdependence of farm and factory in the production of sugar was clearly seen, and with a poor guarantee of acreage the whole factory building scheme was seriously delayed. This delay led to a further difficulty, for the beets of the 1926 crop had to be delivered to the Ipswich factory far away in Suffolk, causing there a considerable congestion and making it necessary for a number of growers to clamp a portion of their crop for delivery in January and February, after the usual manufacturing season.

An attempt to attack some of the outstanding problems of manuring and field treatment was made in a series of experiments centred on Bristol University and carried out in part under the auspices of the Somerset County Agricultural Advisory Committee. Two of these experiments—one concerned with the use of potash, nitrogen and phosphate, and the other with the width of drill rows—were carried out on our farm at Chiselborough, and I can quote the results for what they are worth.

It must be remembered that these figures are the result of single experiments, and they may differ both in sense and value from the results of the whole series when these have been collated by the central authority.

The manurial trial consisted of 8 plots each twelve rows wide and 135 yds. long. The rows were 18 in. apart and the beets were sown on the flat. The plot treatments were as follows :

Plot 1. Complete Manure, less 1½ cwt. muriate of potash per acre.

Plot 2 „ „ { 1 cwt. sulphate of ammonia per acre. 4 cwt. 30 per cent. superphosphate per acre. 1½ cwt. muriate of potash per acre.

Plot 3. „ „ less 2 cwt. superphosphate per acre.

Plot 4. Control, No Manure.

Plot 5. Complete Manure, plus an extra 1½ cwt. muriate of potash per acre.

Plot 6. „ „

Plot 7. „ „ with 6 cwt. kainit in place of 1½ cwt. muriate of potash.

Plot 8. „ „ with 1½ cwt. of sulphate of potash in place of 1½ cwt. muriate of potash.

Each of the plots was divided into three areas, called A, B and C, which received different amounts of nitrogen as top dressings.

Section A had 2 cwt. nitrate of soda per acre.
Section B had 1 cwt. nitrate of soda per acre.
Section C had no top dressing.

The results in yield per acre of washed beets and the percentage sugar contents are shown in the following Table :

Plot No.	*Yield*						*Sugar Content*		
	A		B		C		A	B	C
	tons	cwt.	tons	cwt.	tons	cwt.	per cent.	per cent.	per cent.
1	19	5	19	16	15	6	14·10	18·00	17·04
2	20	12	20	8	16	6	16·68	18·24	20·64
3	21	16	20	0	15	4	15·48	18·54	20·46
4	21	16	19	16	16	2	20·82	17·52	18·42
5	19	5	21	0	18	9	18·06	19·02	22·50
6	20	12	19	16	19	1	17·04	20·58	21·06
7	19	10	18	6	17	18	22·56	18·72	21·72
8	20	17	20	8	19	13	21·06	19·26	17·28

It will be observed that the level of yield was high throughout, even Section C of Plot 4 which received no manure at all producing as much as 16 tons 2 cwt. of washed beets per acre. With such a high level of yield the differences due to manuring are likely to be relatively small, and it is interesting to observe that the first top dressing of nitrogen produced a commercial increase in every case. The limits of experimental error in any set of single plots in a single season must necessarily be very wide, and small differences as between one plot and another cannot be regarded too seriously, but a definite trend over a large number of plots, and covering several different treatments, deserves more careful consideration.

If all the A sections are taken together as representing a plot receiving 2 cwt. nitrate of soda as top dressing, and a similar calculation and average is taken for the other two sections, the following result emerges :

Section	*Yield per Acre*		*Sugar Percentage*
	tons	cwt.	
A (2 cwt. N) . .	20	9	18·22
B (1 cwt. N) . .	19	19	18·73
C (no top dressing) .	17	6	19·89

It appears that the first cwt. of nitrate of soda has increased the gross yield by 2 tons 13 cwt., and that the second dose has caused a further increase of 10 cwt. This rise in yield has been accompanied by a definite fall of sugar percentage, and in order to correlate the two things, and to find out how far the gain in gross weight has been neutralized by loss of sugar content, it becomes necessary to reduce the calculation to terms of sugar per acre.

Section A yielded 75 cwt. of sugar per acre.
Section B ,, 75 ,, ,,
Section C ,, 69 ,, ,,

Taking the same figures and treating them from the point of view of gross cash return to the farm we get the following results :

Section A—Beet at £3, 0s. 9d. per ton = £62, 2s. per acre.
Section B ,, £3, 2s. 3d. ,, = £61, 18s. ,,
Section C ,, £3, 4s. 9d. ,, = £56, 10s. ,,

From these figures it would appear that in this experiment the first cwt. of nitrate of soda was a very profitable investment, but that the second one did not pay for itself.

The figures serve also to stress another point which is sometimes rather neglected. The heaviest yield brought the best return both of

sugar and cash, and the higher sugar percentage of the lighter crop was not sufficient to make up for the serious loss in gross weight.

The other experiment included five plots with the rows from 14 in. to 24 in. apart. Again all the yields were high, but there was a decided difference in favour of the narrow rows. The yields and cash values per acre were as follows :

Distance between Rows	*Yield per Acre*	*Cash Value at 60s. per ton*
in.	tons cwt.	£ s.
14	24 0	72 0
16	22 0	66 0
20	20 18	62 15
22	18 13	56 0
24	19 18	59 10

The results of this one season's experiments are interesting, and although they may not be wholly convincing in all the differences of manuring and treatment which they cover, they serve to form part of a far greater mass of evidence which is being collected in the West. Further, they serve to give some indication of the very satisfactory level of yield obtainable in the West Country under our normal farm conditions. As yet sugar-beet has no definite place in the rotations, and it has been taken generally either in place of mangolds or cereals.

The great advantage which it enjoys in that it is grown on contract for a price per ton, which is known in advance, coupled with the undoubted success of so many of this year's crops, lends very great support to the growing opinion that it should be used on a far larger scale in the West in the future. It seems that the crop might do much to preserve and to extend the arable area. Such an extension, bringing with it the greatly increased cash returns associated with heavy crops of beet, should benefit both the farmers and their workers to a considerable degree.

Beet, with the long harvesting period of three months, is very little damaged by wet conditions in autumn, and thus has another very great advantage over cereals, especially in the Western Counties, where the rainfall is high.

The success of the 1926 crop, and the eagerness with which the growers are seeking to extend their acreage, supports the conclusion that, given suitable land, the crop should present no insuperable difficulties to anyone who is used to growing root crops. The supply of labour for singling remains a critical point, and there is need for a great deal more information about the kinds and quantities of artificial manure to use.

If full advantage could be taken of the crop, and the area under it extended over suitable land, it should do more to put the farming industry on a sound basis than any other crop we have to select from.

EXPERIENCE WITH SUGAR-BEET IN THE MIDLAND COUNTIES

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Agricultural Organiser for Notts.

In 1924, when the Notts. Education Committee decided to draw up and carry out a scheme of manurial experiments on the sugar-beet crop along certain definite lines, it was understood that numerous experiments and field trials had been carried out in various parts of the country, which had, in a general way, demonstrated the value of manurial dressings. It was felt, however, that more evidence was required as to the economic returns obtained under varying classes of soil, bearing in mind its natural or acquired fertility, previous cropping and manurial treatment, and climatic conditions prevailing over a series of years. I should like to mention the fact that Mr N. Howard assisted in carrying out the whole of the work.

It was decided to arrange the experiments so that each series would aim to answer one definite question, such being in each case—

Series 1. The effect of nitrogenous top dressings.
Series 2. The effect of potash.
Series 3. The maximum profitable manuring.

The first two series have been running for three years, and Series 3 for two years, each being tried on two or three farms each year.

Although, as with all experiments on the manuring of sugar-beet, the results over the whole period would appear at first glance to be somewhat contradictory, as a matter of fact definite information has been obtained which will be of practical value. All the plots were duplicated to ensure reliability and to prevent errors due to any abnormal conditions.

Climatic Conditions.—Knowing the enormous influence of varying climatic conditions it was considered advisable to keep careful records of rainfall and temperature from seed-time to harvest.

Series 1—*Nitrogenous:*

Objects: To test the effect of a complete dressing of artificials (*a*) without a top dressing of nitrogen; (*b*) with one top dressing of nitrogen; (*c*) with two top dressings of nitrogen.

Scheme of manuring per acre :

Plot 1. Control (No Manure).

Plot 2. Complete Dressing { 1 cwt. sulphate of ammonia. / 4 cwt. 30 per cent. superphosphate. / 1½ cwt. muriate of potash.

Plot 3. As Plot 2, plus 1 cwt. nitrate of soda at singling time.

Plot 4. As Plot 3, plus a second top dressing of 1 cwt. nitrate of soda two or three weeks later.

1925 *Trials.*—Three centres were selected in the neighbourhood of Newark, the nature of the soil in each case being—

Centre 1. Light sand with gravel.
Centre 2. Good sandy loam in good "heart."
Centre 3. Light loam with gravel.

No farmyard manure was applied directly to the sugar-beet crops. At Centre 1 the adverse effect of drought was most pronounced.

TABLE I

SHOWING YIELD OF WASHED AND TOPPED BEET PER ACRE

Centre	*Plot 1 Control*		*Plot 2 Complete Dressing*		*Plot 3 Complete, + one Top Dressing of Nitrate of Soda*		*Plot 4 Complete, + two Top Dressings of Nitrate of Soda*	
	tons	cwt.	tons	cwt.	tons	cwt.	tons	cwt.
1	4	11	5	6	5	12	6	4
2	10	15	10	19	11	19	12	4
3	6	6	7	10	7	12	7	11

It will be seen that the application of one top dressing at singling gave very little increase of crop over the Complete Mixture Plot at Centres 1 and 3, whereas at Centre 2 there was an increase of one ton per acre, which gave a money return over the Control Plot of £1, 7s. 9d. per acre.

The second top dressing which was applied three weeks later gave a profitable increase at Centres 1 and 2, but a loss at Centre 3.

Nitrogenous Series, 1926.—This season was very favourable to the beet crop, and the effects of dressings of artificial manures were much more pronounced than in 1925. The judicious application of manures proved most beneficial, and 10 to 12 tons of washed and topped beets per acre were obtained on sand soil. Both centres were on the lighter types of soils and at neither was farmyard manure applied direct to the crop.

TABLE II

NITROGENOUS SERIES

Centre	Plot	Yield per Acre Washed and Topped Beets		Per cent. Sugar	Duplicate Plots		
					Yield per Acre Washed and Topped Beets		Per cent. Sugar
		tons	cwt.		tons	cwt.	
Ranby	1	9	5	19·3	9	0	19·5
	2	10	7	20·0	9	0	20·0
	3	11	13	20·1	10	15	20·0
	4	12	13	20·2	12	16	20·2
Warsop	1	9	6	19·1	9	6	19·1
	2	11	7	19·7	12	9	19·3
	3	9	3	18·3	11	15	19·2
	4	10	2	19·2	11	2	19·4

This Table shows the results obtained from the duplicate plots at both centres. A bare comparison of the figures from the two centres appears at first somewhat confusing, but when they are considered in conjunction with the previous cropping and manuring, definite conclusions may be drawn.

At Ranby no very pronounced increase was obtained by the application of a complete dressing (compare Plots 1 and 2), but the net returns over the No Manure Plots were very substantially increased when the top dressing was applied in addition to a complete dressing, and still further increased when a second top dressing was given.

Plots	Average Yield Washed Beets per Acre		Value at 54s. per ton + 2s. 6d. per unit of Sugar over 15·5 per cent.		
	tons	cwt.	£	s.	d.
No. 4. Complete, + two Top Dressings.	12	14	41	16	9
No. 1. No Manure . .	9	2	29	1	8
Increase due to Manures .	3	12	12	15	1
Less Cost of Manures . . .			3	11	0
			£9	4	1

Thus for an expenditure of £3, 11s. on manures there was a net gain of £9, 4s. 1d. per acre.

The same series at Warsop gave very different results. The application of a complete dressing, costing £2, 1s. per acre, gave an average increase of 2 tons 12 cwt. of washed beet per acre, worth £9, 1s. 7d., leaving a net increase of £7, 0s. 7d. due to the dressing. When, however, the top dressings were added, this substantial gain was lost owing to the increased cost of manures and a lower yield. At the Warsop Centre the land was heavily dressed with farmyard manure during the two previous years, and it is probable that the additional nitrogenous top dressings supplied an excess of nitrogen, which resulted in a too-luxurious growth of leaves, and a resulting lower yield owing to late ripening and the non-transference of food materials (with sugar) from the leaves to the root. In contrast with this, the Ranby Centre had received very little farmyard manure during previous years, and the same quantities of nitrogenous top dressings produced very profitable increases in crop.

Series 2—Potash:

These experiments were carried out in 1925 at the same centres alongside the nitrogenous plots and under similar conditions.

Scheme of Manuring per acre:

Plot 1. Control (No Manure).

Plot 2. Complete Dressing { 1 cwt. sulphate of ammonia. / 4 cwt. 30 per cent. superphosphate. / 1½ cwt. muriate of potash.

Plot 3. As Plot 2, less the potash.

Plot 4. As Plot 2, plus an extra 1½ cwt. muriate of potash.

TABLE III

SHOWING YIELD OF WASHED AND TOPPED BEET PER ACRE

Centre	*Plot* 1			*Plot* 2			*Plot* 3			*Plot* 4		
	tons	cwt.	qrs.	tons	cwt.	qrs.	tons	cwt.	qrs.	tons	cwt.	qrs.
1	4	12	3	5	8	3	4	15	0	6	1	1
2	10	15	0	10	19	2	10	12	0	11	10	3
3	6	6	2	7	13	0	6	2	0	7	4	2

A comparison of Plots 1, 2 and 3 shows the effect of a Complete Manure (Plot 2) over the Control (Plot 1); also over the No Potash (Plot 3). Practically no effect is produced by adding phosphate and nitrogen alone, but when potash is included a distinct increase is brought about at each centre. When the potash is doubled (Plot 4) an increase is shown at two of the centres, one of which is notably short of potash.

1926 *Trials.*—These experiments were carried out at the same centres alongside the Nitrogenous Series and under similar conditions of soil and previous treatment.

TABLE IV

POTASH SERIES

Centre	*Plot*	*Yield per Acre Washed and Topped Beet*	*Per cent. Sugar*	*Duplicate Plots*	
				Yield per Acre Washed and Topped Beet	*Per cent. Sugar*
		tons cwt.		tons cwt.	
Ranby . .	1	9 8	19·8	9 10	19·1
	2	8 15	19·6	8 19	19·6
	3	10 16	19·8	9 12	20·8
	4	9 17	19·9	9 2	20·6
Warsop . .	1	9 1	18·7	9 3	18·5
	2	10 16	19·1	11 6	19·0
	3	10 4	18·8	8 4	18·8
	4	12 15	19·7	11 7	18·5

Again, the two centres produced different results from similar manuring, and reference to the previous treatment of the land will show that at Ranby where substantial dressings of potash had been applied during the two previous years no benefit was obtained by a dressing of potash to the crop, and a comparison of yields with those obtained on the top-dressed plots in Series 1 on the same field will show that nitrogen was more urgently needed at this centre.

At Warsop the highest average net return was obtained on Plot 4—*i.e.*, that receiving a double dressing of potash—and reference to the Nitrogenous Series at the same centre shows that a definite increase was obtained by the introduction of potash in the complete mixture (Plot 2, Series 1), but the yield could not be further raised until the potash was increased as shown in Plot 4—Potash Series, as shown by the following Table :

Duplicate Plots	*Average Yield Washed Beet per Acre*	
	Tons	Cwt.
Potash Series 1. No manure . . .	9	3
Potash Series 3. Super and nitrogen . . .	9	4
Potash Series 2. Potash, super and nitrogen .	11	4
Potash Series 4. Potash, super and nitrogen plus extra potash . . .	12	1

Series 3—Maximum Profitable Manuring:

This series was carried out at three centres in 1925 and at the Warsop Centre in 1926 (soil and previous treatment as before).

Objects: To ascertain the maximum dressing of fertilizers which may be economically used.

Scheme of Manuring per acre:

Plot 1. Control (No Manure).

Plot 2. Complete Dressing { 1 cwt. sulphate of ammonia. / 1½ cwt. muriate of potash. / 4 cwt. 30 per cent. superphosphate.

Plot 3. As Plot 2 plus 1 cwt. sulphate of ammonia and 1½ cwt. muriate of potash.

Plot 4. As Plot 2, plus 2 cwt. sulphate of ammonia and 3 cwt. muriate of potash.

Plot	*Yield Washed Beet per Acre*		*Per cent. Sugar*	*Duplicate Plots*		
				Yield Washed Beet per Acre		*Per cent. Sugar*
	tons	cwt.		tons	cwt.	
1	9	1	18·7	9	3	18·5
2	10	16	19·1	11	6	19·0
3	12	19	19·0	14	4	18·7
4	12	6	18·0	10	19	19·7

Plot 3 has given the highest yield in both cases and it appears from this and from previous years' results that dressings greater than that given to Plot 3 actually have a depressing effect on yield.

Conclusions

Nitrogen.—Under normal conditions top dressings of nitrogen, applied early, produce economic increased yields. If, however, the land is rich in organic matter, or is in a high state of fertility and has received heavy dressings of farmyard manure to the beet or previous crop, it is possible that an excess of nitrogen applied by top dressings may not only not increase the yield, but may be positively harmful.

Potash.—A shortage of potash may seriously limit the yield of sugar-beet. If potash has been supplied during the rotation, and the soil contains a sufficiency, any further dressing direct to the beet will not increase the yield and may even be detrimental.

General.—(1) There can be no hard-and-fast rule or standard dressing of manures for sugar-beet, and any scheme of manuring must be based on a knowledge of the soil, previous cropping and manuring.

(2) There is a fairly sharp limit to the quantity of artificials which may be applied with success, and beyond this yields may even be depressed.

(3) *Sugar Content.* — It may be stated with confidence that judicious manurial treatment with artificials is likely to promote quality, but that, on the whole, climate conditions, seed and soil play a more important rôle in this respect. An examination of all the Control—or No Manure—Plots will show that a slightly lower sugar return was obtained throughout than on the manurial plots. Excess of nitrogen is generally responsible for poor quality, but this may be negatived by a sufficiency of other necessary fertilizing constituents, or by favourable climatic conditions. A shortage of potash may also have a depressing effect on quality.

CULTIVATION TRIALS ON SUGAR-BEET. CENTRE—HADSOCK PRIORY

The object of these trials was to obtain definite information regarding the effects of cultivations on the yield of beet, and it is proposed to repeat them during a number of seasons. It should be clearly understood that no definite conclusions can be drawn from this one trial.

In the case of the number of hoeing trials, the object was to test the effect of soil movement, the killing of weeds being a secondary consideration.

Number of Horse-hoeings

Plot			
1	Two—on June 2nd (before singling) and		June 22nd
2	Three	,,	,, June 22nd and July 10th
3	Four	,,	,, June 22nd and July 10th and 17th
4	Five	,,	,, June 22nd and July 10th 17th and 23rd

Yields per Acre

Plot	*Tons*	*Cwt.*	*Qrs*	*Per cent. Sugar*
1	14	6	0	19·2
2	13	16	1	18·5
3	12	19	3	19·4
4	13	11	1	19·1

No increased crop resulted from hoeings in excess of two—*i.e.* one before singling and one after.

Width of Row Trials

Plot	*Width in In.*	*Tons*	*Cwt.*	*Qrs.*	*Per cent. Sugar*
1	16½	13	16	3	18·9
2	19	13	13	2	19·4
3	23	13	19	2	19·3

There was practically no difference in yields. It appears that the additional number of roots per acre does not necessarily mean a greater yield per acre. The difference in the size of the roots was very apparent when the plots were lifted and topped.

Plot	*Date of Singling*	*Tons*	*Cwt.*	*Qrs.*	*Per cent. Sugar*
1	June 7th	13	3	0	20·3
2	,, 11th	12	16	2	19·5
3	,, 16th	12	18	0	19·5
4	,, 21st	12	6	2	20·0

The singling on Plot 1 was carried out as early as the plants could be handled—*i.e.* when showing fourth leaf, and the results show an increase of nearly 1 ton over the plot singled last ; also the sugar content of the crop from this plot was the highest obtained at this centre.

It is too early to draw definite conclusions, further work being necessary.

THE DISCUSSION

Sir Frederick Keeble, in opening the discussion, said that he was greatly impressed, or depressed, by the smallness of the average yield of beet in this country.

He was convinced that this could be greatly bettered by more thorough cultivation of the soil.

The difference between farming and gardening was mainly one of soil conditions, and the difference between the yield of the same crops under the two conditions was enormous.

He thought that the first step to better yield should be cultivation, aimed at the making of good soil conditions, and that this might be followed by improved manuring.

He ascribed the very small increases of yield obtained with nitrogen manures in some of the experiments put before the conference to the operation of the law of limiting factors and not to any essential failure of artificial nitrogen as a manure for sugar-beet. Unless the other factors of growth were in balance, no plant could use the manure given to it to advantage.

He mentioned that in the near future large supplies of new types of nitrogenous and mixed manures would be available on the English market as the produce of our own industries ; and that these should prove interesting to sugar-beet growers and other intensive farmers.

Sir Frederick Hiam said that he had had satisfactory results with beet grown in rows 21 in. apart. He got these by using a 7 ft. drill equipped with four coulters.

Even with rows as far apart as this he had found it very necessary to use a light horse on the hoes as the big shire did a very great deal of damage in kicking up the plants in the rows.

He had found that wireworm was a serious pest to the crop when sown early and he had suffered considerable losses by birds, mostly crows and lapwings, which pulled up the young plants to get at the wireworms. He quite definitely delayed the sowings of his crop to avoid this trouble.

In the matter of manuring he used plenty of farmyard dung, and he had not found that it had had any such depressing effect upon the crop as had some of the heavier artificial dressings mentioned in the papers.

Mr W. F. Giles (Messrs Sutton & Sons), speaking of the production of sugar-beet seed, said that the plant had been grown experimentally by his firm for many years.

During the war, when the import of seed became impossible, Suttons had undertaken a home-grown supply for the Kelham Factory. It was possible to produce satisfactory seed in England in four years out of five, but unfortunately, owing to the high cost of labour here, the cost of production was too great for it to compete with a foreign article of equal, or perhaps greater, germination capacity. The future of sugar-beet seed production in England must depend simply on the cost of production.

In the matter of width of rows and heavy seeding, and their bearing on yield, he recalled an enormous crop of mangolds grown at 16 in. between the rows and with 16 lb. of seed per acre. These yielded 90 tons per acre, and the roots grew practically touching one another. The hoeing on this crop had been done with Planet Junior hoes, pushed by men and therefore without the use of horses. These hoes should be useful to sugar-beet growers using narrow rows.

Mr J. L. Luddington said that he had grown sugar-beet for a number of years and that now he was growing them on ridges with 24 in. between the rows. He found that he was getting a good crop of 12 tons per acre of washed beet and a sugar content of 16·2 per cent.

The final result of this in the way of net return was satisfactory, and the saving in cost of cleaning and hoeing was very considerable. He believed that ridge growing really served to reduce the cost of production per ton.

He had found in his experience that the factories treated the farmers well and he believed that it would be possible to secure the future of the industry as the subsidy dropped, by the production of a larger crop at a smaller cost to the farmer.

Mr A. W. Ling said that in the large series of sugar-beet experiments conducted last year from Bristol University over five Western

Counties, it had been found possible to alter the yield considerably by cultural methods and arrangements, but not the sugar content.

For instance, beet in rows 15 in. apart yielded 22 tons per acre, 18 in. apart, 20 tons per acre, 22 in. apart, 19 tons per acre, without any significant difference in sugar percentage.

This type of result was common among 300 separate experiments under consideration and gave point to the recommendation that the farmer should regard gross yield as the point of paramount importance in his beet crop.

An excess of nitrogen given to the crop either with the seed or as a top dressing was certain to lead to a large leafy growth without an equivalent increase in root. This leafiness was correlated with a delay in maturity which might have serious effects on the crop. As far as he could gather a dressing of 1½ cwt. per acre of sulphate of ammonia or calcium cyanamide before sowing, followed by a single top dressing of nitrate of soda at singling time, gave the best results in the West Country.

Speaking of potash manures, he said that on most light soils the applications of potash to the crop seemed to be profitable, but that on heavy soils—on the old red sandstone, and on the lias and other clays—the plots without potash had often given the best results, and increases of potash had often caused a progressive depression of crop. He thought that the sugar-beet as a plant was particularly well equipped for utilizing reserves of potash already in the soil.

He believed strongly in the necessity for singling at the earliest possible moment, and was curious to know more about the influence of variety on sugar content.

Col. G. H. Long said that during the last season the W. Suffolk Agricultural Committee had conducted a series of experiments with sugar-beet at some six centres in the county. Among other things they had tried different widths of rows (18 in. and 24 in.), but the yields had come out about the same. Many farmers in the district considered that beet grown on ridges 24 in. to 28 in. apart gave as good yields as those grown on the flat at 18 in., while the saving in cost in growing and cleaning them was considerable.

He had found that on thin-skinned land the number of fanged beet was very large unless the subsoil was well broken at the time of first ploughing. He used a subsoiling tine on his ploughs over the whole 100 acres which he intended to put under beet this next year.

He had found that sulphate of ammonia applied before drilling had tended to produce an improvement in the plant obtained. He suggested to Sir Frederick Hiam that the Suffolk horse was far better suited to work between relatively narrow rows than the shire.

Mr Shorten (Howard & Sons) said that his firm was extremely interested in the development of special and improved types of machinery

to help the growers. Recently they had turned out a new sugar-beet lifter, some special types of ploughs, and a hoe which would deal with four rows of beet at a time. He was sure that as improvements in production were outlined the implement makers would be doing all in their power to further them, and to help the growers in their task.

Mr T. THOMSON said that some uncertainty existed in the West Midlands as to the date of sowing and its effect upon the number of bolters produced. In 1925 crops sown on 18th April had practically no bolters, while last year those sown as late as 10th May had many. If late sowing was insisted on as a precaution there was always a difficulty in getting the crop through to maturity.

He was anxious to know how far the beet suffered from exposure on the ridge, as there seemed to be a tendency among growers in Shropshire to turn to ridge cultivation.

Several farmers of his acquaintance who had been accustomed to vegetable growing and who were equipped with Planet Junior hoes had found benefit from the use of these tools in sugar-beet. He thought that there was a critical point of economic balance to be found between the use of horse and man labour in the working and handling of the crop.

It appeared to him that the facts adduced concerning the influence of daylight on sugar formation in the beet supported the opinion that every effort should be made to lengthen the growing season at the beginning.

Mr F. RAYNS said that he had grown sugar-beet last season on the ridge and on the flat with equal distances between the rows on the farm of the Norfolk Agricultural Station. The yield had been practically equal in the two cases, with a very slight difference in sugar content (3 per cent.) in favour of the flat work. This difference was more than counterbalanced by the economy and ease of working on the ridge.

Many successful growers who had used the ridge system in Norfolk last year had earthed up the roots as a final operation, and this had been easy to do. He was convinced that in many circumstances the growing of sugar-beet on the ridge was a sound practical proposition.

Three years' work on the use of nitrogen with sugar-beet had brought him to much the same conclusions as those already mentioned. Increases of yield for the first dressings were soon followed by a check. This year he had applied the whole of the nitrogen by the time of singling and he had got response to a larger total dressings than when the applications had been spread out to a later date. He thought that there was a definite connexion between the use of nitrogen and the number of bolters in the crop.

Sir JOHN RUSSELL, in closing the discussion, first of all thanked the speakers and then stressed the twofold object of the Rothamsted Conferences. They were intended, he said, firstly to get the best information of all kinds bearing upon matters of immediate agricultural interest and to spread that information as widely as possible. Secondly, they were meant to obtain, for the Station, problems from the field that required scientific investigation.

Turning to the subject of discussion he said that the present position with regard to yield was obviously unsatisfactory. There seemed to be three lines of attack in the attempt to better it :

(1) Improvement of varieties to suit situations. Much had been done already, but there was hope of still further progress in this line.

(2) Improvement of cultivation and methods of spacing. In this department there was certainly room for very much more experience and experiment. Preparation of seed bed, depth of sowing, width of rows, ridge or flat—all were important matters requiring exact knowledge and probably local modification.

(3) Manuring might prove to be capable of producing most satisfactory results with sugar-beet as with other things, but great discrepancies were bound to occur until the foundations of cultivation for the crop had been established.

The matter of the time of application of nitrogen and its effect in producing an increase of top rather than root seemed to be bound up with the question of the utilization of the nitrogen by the plant. It was desirable to apply, at the right time, just that quantity of nitrogen which the plant could use in the production of the maximum amount of that type of growth which we might require. The extra nitrogen taken to produce unnecessary leaves in the beet was obviously ill applied even though it might be producing an increase in the total weight of the plant.

SUMMARY OF POINTS

BY C. HEIGHAM, M.A.

Rothamsted Experimental Station

Nature and Position of the Crop

(1) The growing of sugar-beet by a farmer and the making of sugar by a factory are to be regarded as parts of a single process of production. It is necessary for the continued success of either party that the two shall work together in close accord and sympathy.

(2) Sugar-beet being a comparatively new crop to this country there is no traditional method of growing it built up on generations of

field experience. There is much valuable information to be obtained from the Continent, but this must be tested under the local conditions of our own beet-growing districts before it can be used here with full advantage.

(3) The crop at present enjoys a degree of State protection which will decrease in future years. The period of subsidy is to be regarded as a time of education and experiment during which commercial machinery may be established and the growers may accumulate such knowledge and skill as will enable them to compete successfully in the open market.

(4) The yield of beets on many of our farms is unsatisfactory, and the average must be increased from 8½ tons per acre to at least 10 or 11 tons per acre if the industry is to maintain itself in the future.

(5) Beet of high quality can be obtained in many parts of the country, and given good methods of production and adequate manufacturing facilities there is room for a greater development of the crop.

Factory Requirements

(6) In order to work to the best advantage the factory requires a regular supply of beets spread over the manufacturing period from October to the New Year. It is essential that growers should keep closely to the terms of their contract, as the factory organization depends on this.

(7) The factory obtains the best working results from beets containing a high percentage of sugar, and is seriously hindered by consignments which are not properly topped or which contain many bolters or much rubbish in the form of stones, weeds, etc.

(8) The overhead charges of the factory and its permanent staff of all kinds have to be spread over the number of working days in the year. The longer the period of full working the less per ton will these charges be. The English factories enjoy an advantage in that they have a working period of 100 days as compared with 40 to 80 days in some other countries.

Growers' Requirements

(9) Growers require an assured market for their product, and the fact that the price of sugar-beet is fixed in advance of the crop may be of great importance in stabilizing the finances of a farm in difficult times.

(10) At present much local information is needed on such matters as varieties of beet to grow, the best cultivations to use, and the most economical manuring.

(11) Short haulage and a cheap rate of transport to the factory are points of great importance in deciding the success of a crop. Bad roads,

long journeys to the station and long railway transport with high charges should be considered in detail before the contract with the factory is signed.

(12) An adequate labour supply in the spring and autumn—the critical seasons of the crop—is a matter of the first importance. The chances of obtaining the necessary labour when he wants it should be explored by the grower before he undertakes production of the crop.

(13) At the present time, and on the terms of existing contracts, high gross yield is more important to the grower than high sugar content if these two cannot be obtained together.

Each 1 per cent. of sugar below 15½ per cent. is worth 3s. 5d. per ton, while each 1 per cent. over that figure is paid for by the factory at 2s. 6d. per ton.

(14) The crop employs a good deal of costly labour, and therefore any labour-saving devices which can be applied in any stage of its treatment may have a very great influence in lowering the cost of production per ton.

The Requirements of the Crop

(15) The yield of the crop will depend very largely upon the number of plants grown to the square yard and the acre. Continental experience suggests that 8 plants per square yard is the optimum number. This is obtained by using narrow rows (14 in. to 16 in.), and singling to 8 in. apart. Many English crops have not more than 4 beets per square yard with a full plant.

(16) Whatever width of row or singling distance is used, it is desirable to obtain a "full plant" and to have as few gaps as possible. To obtain this with certainty a heavy seeding, 15 lb. to 20 lb. of seed per acre, is generally recommended.

(17) The seed bed should be fine and moist at the top, with the lower layers well broken to allow easy penetration of roots. The seed should be sown regularly and at a depth of not more than 1 in. The roller is a very important implement before, during and immediately after the seeding.

(18) Singling of the crop is an operation of critical importance. It should be done carefully and methodically as soon as the plants have four leaves. Each chosen individual should be left well planted at its regular distance from its neighbours.

(19) Hoeing by horse and hand should continue till the leaves of the plants meet in the rows. The exact number of times which the hoes should pass through the crop must depend on the soil, the season and the cleanliness of the field. The skill of the grower must be applied in deciding this in each case.

(20) Distance between rows and the use of flat or ridged seed beds must depend in some degree upon the soil, the local traditions in root

growing, and the grower's equipment of implements, horses and men. It appears that in general the narrower rows produce the best crop both in yield and sugar percentage, but there may be many exceptions to this rule.

(21) The question of subsoiling for the crop has to be considered on thin-skinned soils. A great deal of Continental experience goes to support the idea that on all but the deepest soils subsoiling should be a routine operation in the growing of sugar-beet. A number of English growers with experience are now using subsoiling tines on their ploughs.

(22) In general it may be said that problems of cultivation require to be attended to thoroughly before specific problems of manuring come to be considered. With sugar-beet in England at the present time there is great opportunity to increase the yield of the crop by an improvement of cultural methods.

(23) Good crops of sugar-beet have been grown in many districts with the manuring commonly used for the mangold crop. Sugar-beet being a more highly priced crop than the mangold may pay for a heavier application of fertilizers, but at present there is no special recommendation which suggests that its needs as a plant differ widely from the better-known root crop.

(24) There is need for properly co-ordinated experiments to be conducted throughout the beet-growing areas of the country to investigate the manurial needs of the crop under the very various conditions of soil and climate found within our borders.

(25) The climatic conditions of our country are particularly well suited to the successful production of sugar-beet. The long periods of daylight favour sugar production in the plant. The moderate average temperature during the growing period encourages steady and even growth in the field. The comparatively long period of harvest (100 days) brings a great advantage both to the farmer in his harvesting operations and to the factory in its business of slicing and sugar extraction. The absence of extremes of heat and cold makes it unlikely that the beets will be either severely checked in growth or badly damaged by frost before they can be delivered to the factory.

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