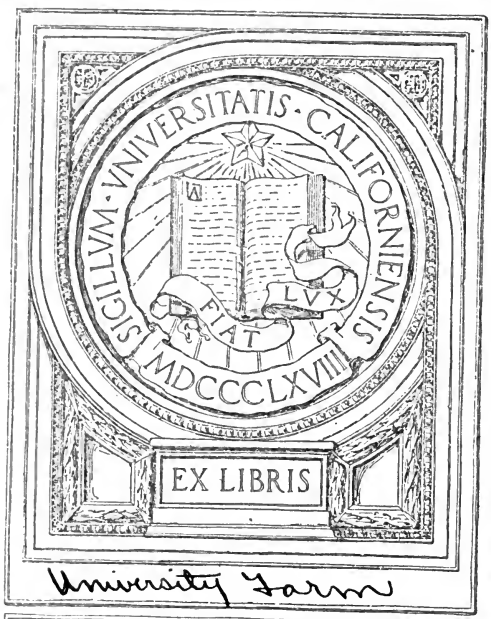
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FORAGE CROPS IN DENMARK

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THE FEEDING VALUE OF ROOTS
SELECTED STRAINS OF ROOTS AND GRASSES
GUARANTEES IN THE TRADE IN SEED

BY
HARALD FABER
AGRICULTURAL COMMISSIONER TO THE DANISH GOVERNMENT

WITH A FOREWORD BY
SIR ROBERT GREIG, M.C., LL.D., M.Sc.
BOARD OF AGRICULTURE FOR SCOTLAND

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FOREWORD

So much has been written about Danish Agriculture that it would seem as though little remained to be described. It is only the main features, however, of the progress of that fascinating country that have been placed before British readers. We are, or we ought to be, familiar with the systems of tenure, methods of farming, experiments in co-operation and organisation of marketing.

In his book, "Co-operation in Danish Agriculture," Mr. Harald Faber has given us a vivid picture of the growth of prosperity in Denmark through co-operation. Nevertheless, in spite of that and of other equally instructive books, there remain to be explained to us some of the original and ingenious methods by which the production of Danish soil has increased so remarkably. In the present volume—"Forage Crops in Denmark"—light is thrown on several experiments, and developments therefrom, which are not sufficiently known in this country.

The origin and spread of root cultivation in England, and later, in Scotland and Ireland, is an old story, and the effects upon the systems of farming and even upon the health of the people are well known to every student of agriculture. It is a question if we have not carried the cultivation of roots and the prominence of roots in the rotation beyond the economic point. It is certain, at all events, that we have not attempted to fix the feeding value of roots on the comparative basis which has been adopted by Denmark. The Danish farmer grew small areas of roots and thought little of them as feeding material. In consequence his land was not kept too clean and his bill for imported or home grown cereals and other products for cow feeding was heavy. In this book we are told not only how the Danish farmer was induced to give a greater place to roots in

his rotation, but how and to what extent the turnips and mangels could be substituted for the more expensive materials then used for milk and pork production.

A remarkable series of experiments carried out at the Laboratory for Agricultural Research, Copenhagen, showed that the despised roots not only increased the production of milk, but that, in general, the dry matter in the roots had the same food value as the same amount of grain. In other words, one pound of grain in the ration of a milk cow could be replaced by such a quantity of roots as contained one pound of dry matter. One of the striking effects of these experiments was to increase the area of root-crops in Denmark from 6000 acres in 1861 to 678,000 acres in 1919. Whereas in former days the root-crop area in Denmark was almost negligible, the percentage of mangels, swedes, and turnips to the total acreage under crops and grass is now 9·7 in Denmark as compared with 5·4 in Great Britain.

The Danish farmer having learned that the dry matter in the roots which he grew was as effective as the dry matter in his grain crops for producing milk, naturally set himself to find out if the total quantity of dry matter from his turnip fields could be increased. The first movement in that direction was to discover superior strains of seed which would give, in the first place, larger crops. By experimenting and applying the results of the experiments the average yield of mangels increased from 16 tons per acre to 21 tons per acre in a few years. A good cropping strain alone was not enough, however. What was wanted was a strain yielding larger quantities of actual feeding material. It was found, for instance, in one of the experiments, that one strain of mangels producing a very large crop with a low percentage of dry matter actually yielded a smaller quantity of feeding material than a smaller crop grown on the same field but of a superior strain. The bulky crop required the farmer to cart fifty additional loads of water from his field without getting any more feeding material for his stock.

It was therefore attempted to ascertain the superior strains, those yielding the largest amount of feeding material per acre. The book must be read in order to appreciate the ingenious and successful method by which those strains were discovered and

isolated. It is enough to say here that outstanding success rewarded the investigators, and growers of strains of the first class are able to obtain as much as £2 to £3 per pound for their accredited seed. One of the encouraging features of these trials is the continual striving after still greater success. The strain of mangels which is to-day incomparable may become, in a few years' time, second or third rate. Other strains may come to the front and be demonstrated to be of greater value. One result of these trials is to show that the Danish seed produced in Denmark is superior to the seed imported from abroad, and whereas Denmark was formerly a large user of British and of foreign grown seeds the tables have been turned and Denmark is now an exporter of seed to other countries.

Work of selection and improvement has been done by seedsmen and private firms in this country, and to them we are, as agriculturists and food producers, very greatly indebted. No comprehensive and State aided attempt has yet been made, however, on the lines of this Danish experiment, and there is no doubt that a valuable and fertile field for such research lies open to the Agricultural Departments and Agricultural Research Stations of the United Kingdom.

Another section of Mr. Faber's book is devoted to the improvement of grasses by selection. In grass farming as in root growing Denmark was capable of great improvement up to about 1875. A great change then took place through the exertions of one man who began life as an agricultural labourer at the age of ten. Later on, he became a schoolmaster, and his name—P. Nielsen—is now well known to all agricultural improvers of arable crops. It was Nielsen who introduced the system of small "parallel" plots for experimental purposes in place of large fields, and this method of small plots in duplicate or triplicate has been almost universally adopted by other experimenters. The grass seed of Denmark in those days was exceedingly bad. Good samples would germinate only about 25 per cent., and it was difficult to discover where good samples could be obtained. Most grass seed was such as the farmers saved from their own fields. The great advance was made when a socie for the cultivation and sale of Danish grass seed was formed. This and other affiliated societies have aroused

an interest in improving seed which has had the best effects on the grass farming in Denmark. Denmark used to import grass and clover seeds from abroad in large quantities. Among other importations was that of Irish Italian Rye Grass, but it was soon found that the Danish strains were the more prolific and better able to resist rust. The State Committee on Plant Culture decided in 1908 to arrange for comparative trials of strains of grass and clover seeds on the same lines as had proved so successful with roots. The methods by which those trials were carried out and the great success which has attended them will be found in " Forage Crops in Denmark." Seedsmen entered their best strains for competition. Farmers, who had developed a good strain, sent it to be tested. At first the seedsmen were suspicious of these trials, but when it was discovered with what great care they were carried out by a Committee of the State Department of Plant Culture, their suspicions were allayed; and the largest merchants now regard this competition as an indispensable aid to honest and genuine trade. The book must be read to ascertain how the dishonest and ignorant seed merchants and bad seed have been eliminated, and the honest and enterprising seed firms and seed growers have been encouraged.

The last chapter of the book describes how a buyer of seed is assured of receiving the seed of the particular strain which he demands. The reader will learn how twenty-one firms and associations dealing in seed and using an aggregate quantity corresponding to two-thirds of all the seed used in Denmark have now voluntarily submitted themselves to a Control, with the result that there is no other country in the world where the control of the seed used by the farmers is so extensive and so careful. The Danish Seed Testing Station was the first in the world, and it is by and through this Station that the control of seeds is accomplished.

The description of how, partly by educational propaganda, the pressure of public opinion, and to some extent by legislation, the seed trade of Denmark was put upon a sound, and, from our point of view, an enviable basis, is one of special interest to the farmer and seed merchant of this country. It is only lately that an attempt has been made to control the purity and

germination of seed in Great Britain. Our best seed merchants have long been aware of the desirability of purchasing and selling their seeds upon a basis other than that of mere appearance or price, but much remains to be done to level up the whole trade of the country to the conditions of the firms of the highest reputation. In Mr. Faber's book will be found the information which explains how this has been done in Denmark.

The impression left upon readers of this book will be one of admiration for a country which has so effectively helped itself. It has not depended upon State aid alone. It has been assisted from time to time by the State, but the origin of the improvements and the driving force to bring them into being have come from the farmers themselves. It would appear that in Denmark the traditions of the people and their educational system enable them more quickly to appreciate the possibilities of improvement and the means to carry them out. In this country we lack neither initiative nor enterprise, but we seem less ready to adopt and attempt new methods and less inclined to combine and bring about improvements in agriculture than is the case in Denmark. It is true that British Agriculture has shown signs of new life within the last few years, and there is evidence on all sides of concerted attempts on the part of farmers to unite money and brains in the development of agriculture. Those who are taking part in this union, those who are interested in the development and reconstruction of agriculture, and every teacher and student of crop production and arable farming, will find Mr. Faber's book, " Forage Crops in Denmark," stimulating and instructive. Mr. Faber is to be congratulated on his enterprise in placing before British readers so much that would otherwise be unknown, and we in this country have reason to be grateful for his services.

R. B. GREIG.

PREFACE

The growing of forage crops has been developed in Denmark during the last twenty or thirty years more than any other branch of agriculture. From 1888 to 1919 the acreage under roots increased sevenfold, from 95,000 to 678,000 acres. In attempting to show how this development has been brought about, I begin with the classical feeding experiments of N. J. Fjord, because they first proved to Danish farmers that it paid to grow roots. Fjord devised an original method of ascertaining the relative value of corn, cakes, roots, milk and whey, as food for cows and pigs, and proved that one pound of dry matter or solids in roots was equal in feeding value to one pound of corn. Since two-and-a-half times as much dry foodstuff can be produced on an acre by growing roots as by growing barley, farmers took to growing roots largely. The next two chapters deal with a system of Comparative Cultivation Tests with strains of roots and of grasses, carried out on behalf of the State Committee on Plant Culture by L. Helweg and E. Lindhard, on the Experimental Stations of the State. The object of these tests is to find the strains of roots which give the highest yield of foodstuff, or dry matter, per acre, and the strains of grasses which give the highest yield of hay. By the published results of these competitions farmers learnt to buy seed of the most productive strains, and the trade in seed changed its character. The last chapter deals with the guarantee of seed not only as to purity, germination and other data of analysis, but also as to genuineness of strain. To guarantee the genuineness of strain is a totally new departure in the trade, which necessitates the co-operation of official institutions. It is undertaken voluntarily by seed merchants and exporters.

I have aimed at showing the inner working of the development. It is often supposed that the Danish Government initiates the various new departures in the agricultural development; but that is not so, as I have also tried to show in a previous publication ("Co-operation in Danish Agriculture," 1918). The initiative to the various steps in the development of the forage crops has been taken by farmers, sometimes in co-operation with merchants, or as the result of the work of scientifically-minded men, often of small means. A good deal of useful information and material was obtained from farmers and seed merchants in Great Britain and other countries. In several cases where it appeared that useful work, begun by private initiative, could not be kept going without support, or where a wider application of a method, proved to be good, was considered desirable, did the State step in to support or to take over such work. The State did, indeed, on one occasion try to take the lead by a Bill to regulate the trade in seed, but the Bill was opposed and fell through; after which, by gradual education and voluntary action, all that was aimed at by the Bill, and even more, was accomplished some years later, culminating in the guarantee of genuineness of strain. The following pages will give many proofs that this has been the system of the development, the aid of the State being Help to Self-help.

For all the very useful and encouraging help so freely given me by experts, both in Great Britain and in Denmark, I hereby render my grateful acknowledgment.

HARALD FABER.

LONDON,
January, 1920.

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FORAGE CROPS IN DENMARK

CHAPTER I

THE FEEDING VALUE OF ROOTS

The cultivation of roots other than potatoes was very much neglected in Denmark even as late as the middle of last century. In his admirable "Report on the Agriculture of the Kingdom of Denmark," [1] H. M. Jenkins, F.G.S., the secretary of the Royal Agricultural Society of England, speaks of "the insignificant proportion of tillage area (not one-quarter per cent.) which is annually under root-crop," quoting from Prof. Wilson's report from 1867, reprinted in the *Journal* R.A.S.E. for 1867 and 1868. The reason often brought forward by Danish farmers that bare fallow was necessary to clean the land, Jenkins answered by expressing the opinion that "the growth of root-crops would be a much more effectual means of obtaining that result," and both he and Wilson found the land very foul, as did also M. Tisserand in 1863. The small acreage of turnips grown is explained by Jenkins as due to "the scarcity of labour and the ignorance of both farmers and labourers on the subject," and to the fact that "root-crops are not esteemed as a food for dairy cows," it being feared that the roots would injuriously affect the flavour of the butter. "Thus in the dairy districts bare fallow is preferred to a turnip-crop, because turnips taint the butter, and there are no steers to feed."

The objection to roots as food for dairy cows was later on found to be largely due to a misunderstanding, and with improved dairy methods it was removed altogether. The land

[1] *Journal* of the Royal Agricultural Society of England, 12 vol., Part II., London, 1876, p. 327 ff.

under roots, which in 1861 was 6000 acres, increased slowly, and was in 1871 16,600, and in 1881 45,700 acres,[1] this latter area being only two-thirds of one per cent. of the arable land, while at the same time in Great Britain 13 per cent. of the arable land were under such root-crops. Several Danish landlords and prominent farmers visited England and Scotland and studied the growing of roots as well as other agricultural methods in vogue. The Royal Agricultural Society of Denmark in 1876 sent M. P. Andersen, a graduate in horticulture from the Royal Agricultural College, Copenhagen, to Scotland and England to study agriculture and particularly seed culture, and three years later the same Society sent Erhard Frederiksen, a farmer, to study root cultivation, particularly in the eastern counties of England.[2] Many articles appeared in Danish agricultural papers recommending farmers to cultivate roots, and the subject was discussed at agricultural shows and other meetings, opinions being divided. With the change of system from corn-growing to animal production, caused by the rapidly increasing import of cheap corn from overseas, the growing of roots for cattle-feeding became more general, and in 1888 the acreage under mangels, turnips and swedes had reached 95,000 acres,[3] and was extended year by year.

But still Danish farmers did not value roots very highly as food for cattle. One prominent farmer even went so far as to say that so long as he had plenty of water in his well he failed to see the use of carting it from the fields in the shape of mangels. When another farmer complained that his roots were frozen and began to rot, a friend consoled him by saying that he might cart them to the dung-hill, which was in any case the best use to which roots could be put, frozen or not frozen. The use of roots as fodder for milch cows was often under discussion among Danish farmers. While some maintained that by giving roots as an addition to the usual ration they obtained a larger yield of milk and of butter, others were strongly of opinion that the larger yield of milk, if such was

[1] Falbe Hansen og Scharling, "Danmarks Statistik," Vol. 2, 1887, p. 199.
[2] "Aarsberetning om det kongelige Landhusholdningsselskabs Virksomhed," København, 1877, p. 55, and 1880, p. 103.
[3] Harald Faber, "Co-operation in Danish Agriculture," Longmans, Green & Co., 1918, p. 163.

obtained, was due only to a larger percentage of water in the milk.

The want of reliable information as to the feeding value of roots was felt so much by leading farmers that they persuaded N. J. Fjord, lecturer at the Royal Agricultural College, Copenhagen, to make some tests for the purpose of finding the value of roots as compared with other feeding-stuffs. He was particularly fitted for the work, having already in 1883 ascertained the relative values of hand-skimmed and machine-skimmed milk as food for calves and pigs in order to meet the objection to the use of machine-skimmed milk which had been raised from several quarters, and which threatened to delay the introduction of the cream separator into the dairy industry. He had shown that the difference in the feeding values of the two kinds of skim-milk, in itself very small, was only due to the larger amount of butter-fat left in the hand-skimmed milk, and had proved that it was obviously not good economy to feed butter-fat to pigs when it could be extracted by means of the cream separator and turned into butter.[1]

He approached the question of comparing the different feeding-stuffs in a thoroughly practical common-sense manner, which made the results easily intelligible to farmers and at the same time gained their absolute confidence.

His leading idea was this : If you want the animals to show you what result a certain feeding-stuff has on their growth or their production, you must keep them and feed them on the farms, in that manner in which practical farmers are in the habit of keeping, and feeding them ; you must work with groups of animals ; the groups must be as nearly alike as possible in respect of average age, weight, growth and production of the animals, and must be sufficiently large to eliminate individual differences in the animals ; you must work with groups of animals carefully selected, so that when fed alike they will increase or produce alike ; you must then make some change in the fodder of one or more of the groups of animals while keeping the fodder of one group unchanged, so that the groups of animals can show whether or not they are equally well nourished by the different feeding, but you must keep within

[1] N. J. Fjord, " 19 Beretning om Forsøg," København, 1883.

the limits of feeding which practical farmers would adopt; you must continue the different kinds of feeding for a sufficiently long time to make sure that the difference, if any, between the different groups in growth and production is maintained, and that it really is the result of the different feeding; and you must conduct your experiments on several different farms, working on each farm according to the habit or experience of the farmer; and finally, to eliminate the possible influence of the seasons, you must repeat the experiments in different years, to make sure that you always get the same result.

These are sensible rules, but they can obviously be followed only if one can induce a sufficient number of farmers to co-operate in the experiment, to place a sufficient number of animals at one's disposal, to provide the necessary premises, and afford the necessary facilities for the Control to obtain the required records of food consumed, of increases in weight, of milk produced—if working with milch cows—and any other data wanted according to the previously arranged scheme, in the drawing up of which the farmers are to be largely consulted. It means, in other words, that the feeding trials must be conducted all over the country, not only for, but with, the farmers, giving them a large share both in deciding how the animals are to be kept and fed and in carrying out the work itself. The direction or controlling of the experiments only must be the work of the manager and his assistants, and he must have at his disposal a large scientifically equipped and staffed chemical laboratory, where the feeding-stuffs and the produce can be analysed. A paid stockman must be placed on each farm, whose duty it is to weigh out the food daily to each group of animals, to weigh the animals every ten days, to weigh the milk from each cow morning and evening, and to take samples of the feeding-stuffs and of the milk. Travelling assistants must be sent to visit each farm every five or ten days, to see that all instructions are carried out, and to make tests of the fat in the milk, and send samples of the mixed milk from each group to the central laboratory, and to keep records of all particulars.

I have dwelt so long on a general description of the scheme of these feeding trials because the value of the results depends on the way in which they have been obtained.

Before coming to the trials dealing with the feeding value of roots, which was tested by feeding both pigs and cows, it will be necessary to mention briefly the results of the first large group of trials carried out in 1884–87 on nine farms, with 487 pigs in 89 groups, and forming 27 separate series of experiments. The results showed that 1 lb. of rye and 1 lb. of barley had the same feeding value; that 1 lb. of corn, 6 lbs. of skim-milk, and 12 lbs. of whey had the same feeding value for pigs, that is to say, that within the limits of a reasonable composition of pigs' food, one pound of corn in the food could be replaced by 6 lbs. of milk or by 12 lbs. of whey without affecting the growth of the pigs.[1]

In 1888–89 another series of feeding experiments was carried out with 444 pigs in 82 groups on 13 different farms. The above-mentioned result, namely, that 1 lb. of corn, 6 lbs. of skim-milk and 12 lbs. of whey can replace each other in the feeding of pigs, was fully confirmed, and the feeding value of roots was inquired into at the same time.[2] The roots were fed raw but chopped in a machine. The feeding value of roots was compared with that of corn, and of milk, and of whey. Six groups of pigs were required on each farm to carry out the full scheme. Two groups were fed in the usual way on the farm, being given corn, and one group some milk, the other group double as much whey. The food on one farm, for instance, consisted of 10 lbs.[3] of barley and 50 lbs. of milk to each pig in one group; 10 lbs. of barley and 100 lbs. of whey to each pig in the other group, and 10 lbs. of butter milk to pigs of both groups, this being the food for one pig in ten days. As the animals grew the food was increased, two months later, for instance, being 17 lbs. of barley and 92 lbs. of milk or 184 lbs. of whey, and 10 lbs. of butter-milk, for each pig in ten days; two months later again 22 lbs. of barley, 118 lbs. of milk or 236 lbs. of whey, and 10 lbs. of butter-milk. On another farm a beginning was made with 13 lbs. of barley, 68 lbs. of milk or 136 lbs. of whey, and 10 lbs. of butter-milk for each pig, and so

[1] N. J. Fjord, "25 Beretning om Forsøg," København, 1887.
[2] N. J. Fjord, "29 Beretning om Forsøg," København, 1890.
[3] Although for practical reasons the weights are given in English pounds (lbs.), it should be remembered that the original really refers to Danish pounds, being 10 per cent. larger than English lbs.

on. In other words, these two groups, called respectively A and B, were fed with the quantity of corn and either milk (A) or whey (B), with an addition of some butter-milk, which represented the ordinary or normal feeding at the time on these farms. Similarly on the other farms.

In order to test in what proportion mangels could take the place of corn in the feeding of pigs, two other groups of pigs, called C and D, were fed with only half the quantity of corn given to A and B, the other half being replaced by mangels; the same quantity of milk (to C), or of whey (to D), was given as that given to A and B, with the same quantity of butter-milk.

Two more groups, E and F, had the normal quantity of corn, as given to A and B, and the same quantity of mangels as C and D, with a corresponding deduction from the quantity of milk and whey. This was done to test whether this quantity of mangels could replace the quantity of milk, or of whey, which in feeding value corresponds to half the normal corn food. The measure of the feeding value of the food given was the increase in the weight of the pigs, which was ascertained after each period of ten days.

It was first tried whether 10 lbs. of mangels was a fair equivalent for 1 lb. of corn, or 6 lbs. of milk, or 12 lbs. of whey. The ten days' supply of food per pig in the six groups on the first mentioned farm was, in the first period of 10 days :—

	Butter-milk (common for all).	Corn (barley).	Skim-milk.	Whey.	Mangels.
	lbs.	lbs.	lbs.	lbs.	lbs.
Group A . . .	10	10	50	—	—
„ B . . .	10	10	—	100	—
„ C . . .	10	5	50	—	50
„ D . . .	10	5	—	100	50
„ E . . .	10	10	20	—	50
„ F . . .	10	10	—	40	50

In the food of groups C and D 5 lbs. of corn were replaced by 50 lbs. of mangels. As group E and F were to have the same quantity of mangels as C and D, 30 lbs. of milk, being equivalent to 5 lbs. of corn, were deducted from the food of

group E, and 60 lbs. of whey, being also equivalent to 5 lbs. of corn, were deducted from the food of group F. In the latter periods of ten days each, when the food was increased with the increased size of the pigs, the corresponding changes were made, always replacing corn, milk and whey with roots in the same proportion. In the last period of ten days, for instance, the food supplied to each pig in the six groups was :—

	Butter-milk.	Corn (barley).	Skim-milk.	Whey.	Mangels.
	lbs.	lbs.	lbs.	lbs.	lbs.
Group A . . .	10	22	124	—	—
„ B . . .	10	22	—	248	—
„ C . . .	10	11	124	—	110
„ D . . .	10	11	—	248	110
„ E . . .	10	22	58	—	110
„ F . . .	10	22	—	116	110

Thus 11 lbs. of corn, or 66 lbs. of milk, or 132 lbs. of whey, were tested against 110 lbs. of mangels.

The average increase in weight during the whole time of the experiment, calculated in lbs. per pig in 10 days, should be the same for group A and B, if 1 lb. of milk and 2 lbs. of whey have the same feeding value, as the only difference in the feeding of these two groups was, that A had a certain quantity of milk and B double the quantity of whey. The average increases for the whole time, from 10th Nov. to 29th March, were for A 7·6 lbs., for B 7·6 lbs. Similarly for C and D, which were fed alike except that C had milk and D had whey. The average increases for these groups were 8·2 lbs. for C and 8·4 for D, as nearly alike as can be expected. Similarly for E and F, the increases per pig in 10 days were 8·4 for E, 8·7 for F. This experiment, therefore, proved that the previously established result, that 1 lb. of skim-milk and 2 lbs. of whey have the same feeding value for pigs held good also when part of the food consisted of roots.

But when we compare the effect of replacing half the corn, or the corresponding quantity of milk or of whey, by mangels in the proportion of 10 lbs. of mangels to 1 lb. of corn (or 6 lbs. of milk or 12 lbs. of whey) it will be seen at once that 10 lbs. of mangels are more than the equivalent of these quantities of

the other feeding-stuffs. The average increases per pig in 10 days were :—

	lbs.	lbs.	lbs.
For the groups A—C—E	7·6	8·2	8·4
„ „ „ B—D—F—	7·6	8·4	8·7
Average . . .	7·6	8·3	8·6

In other words, the groups of pigs which had mangels, namely, C, D, E, and F, increased at a greater rate than the groups which had none (A and B).

The experiment was, therefore, repeated with other groups of pigs on the same and some other farms, but giving only 8 lbs. of mangels in place of 1 lb. of corn, or 6 lbs. of milk, or 12 lbs. of whey. It will be enough to give the average results for the six groups in these series, showing the average increase in weight for one pig in 10 days, which were :—

For Groups	A and B.	C and D.	E and F.
	lbs.	lbs.	lbs.
51 series	8·6	8·8	9·1
52 „	8·4	8·7	8·8
53 „	8·6	8·3	8·9
Average . . .	8·5	8·6	8·9

The final result of these series of feeding experiments was then, that, as food for pigs, 8 lbs. of mangels were fully equivalent to 1 lb. of corn, or 6 lbs. of skim-milk, or 12 lbs. of whey.

These feeding experiments were followed with the keenest interest by leading members of the "Society for Improving Cultivated Plants." As a result of several years' comparative trials they had found that there was a considerable difference in the contents of dry matter or total solids in roots of different varieties or even of different strains within the same variety. They were, therefore, anxious to have different kinds of roots tested in Fjord's feeding experiments, in order to see whether the feeding value of different kinds of roots stood in any relation to their contents. In December, 1888, the Society approached Fjord, suggested that two different kinds of roots—Eckendorf, a German variety, and Elvetham, an English variety containing

more sugar—should be compared, and offered to supply the seed. The offer was accepted, the seed supplied by L. Helweg, the director of the Society's practical work, was sown in the spring of 1889 on two large farms, a quantity of seed of each of the two kinds being divided between the two farms. When the roots were harvested in the autumn they were analysed. It was then found that on the first farm the Elvetham and Eckendorf mangels contained 10 per cent. and 8·8 per cent. of sugar respectively, or that they were not very different in that respect and less than expected. On the other farm the roots of both kinds contained very much less sugar although grown from identically the same seed as on the first farm. The Eckendorf, which on the first farm contained 8·8 per cent. of sugar, contained on the second farm only 4·5 per cent., and the Elvetham only a little more. The explanation of this peculiar occurrence that seed of the same strain of mangel gave such widely divergent results on two different farms has been investigated by Helweg,[1] and he has found that certain soils, consisting of mud, such as are met with on land reclaimed from inland lakes, have the peculiarity of producing roots with a small contents of sugar and with at the same time a slightly increased contents of other solids. Helweg grew 17 different strains of 10 different varieties of mangels on ordinary soil and on reclaimed muddy soil, and in each case these differences in contents were found. On the average the 17 strains contained of total solids 11·5 and 8·9 per cent., and of sugar 9·1 and 5·8 per cent., respectively on ordinary soil and on reclaimed soil; but those strains which gave the best results, that is, had the highest contents, on ordinary soil, were also the best on the reclaimed soil. The soil of the root field on the second farm was like such reclaimed soil.

As the idea was to try the effect on the growth of pigs of feeding roots with a high and a low contents of sugar or total solids, it was decided to cart from the first farm to the second a sufficient quantity of Elvetham roots in order to use them for feeding the pigs there. On both the farms two groups of pigs, called C and E, were fed with Eckendorf mangels, and on both farms two further groups of pigs, called C_1 and E_1, were

[1] "Om Landbrugets Kulturplanter," København, 1892, p. 173.

fed with the same quantities of Elvetham mangels. But while the Eckendorf roots were grown on the farms where they were used, the Elvetham roots used on both farms were taken from those grown on the first farm. The contents of sugar in the roots fed to the different groups of pigs were, therefore:—

		Sugar. per cent.	Total solids per cent.
On the first farm, for groups	C and E, Eckendorf with .	8·8	12·7
„ „ „ „	C_1 and E_1 Elvetham „ .	10·0	14·8
On the second farm, for groups	C and E, Eckendorf „ .	4·5	9·3
„ „ „ „	C_1 and E_1 Elvetham „ .	10·0	14·8

When the feeding experiments with these groups were concluded it was found that the average increases in weight per pig in ten days were:—

On the first farm, for groups	C and E .	8·6 and 8·9 lbs. respectively
„ „ „ „	C_1 and E_1 .	8·7 and 8·6 lbs. „

or about the same, corresponding to the somewhat similar contents of the two kinds of root used there, but:—

On the second farm, for groups	C and E .	7·6 and 8·4 lbs. respectively
„ „ „ „ „	C_1 and E_1 .	8·9 and 9·3 „ „

or a considerably greater increase of the pigs which had the "sweeter" Elvetham roots, *i.e.* roots with the higher contents of sugar and dry matter.

This experiment, therefore, gave a very clear indication that the feeding value of roots depended on the contents of the roots. This gave a hint to growers of roots which was not lost on them, that it would be of advantage to grow such roots as yielded the greatest amount of feeding-stuffs per acre. But as Fjord did not consider it safe to draw a definite conclusion from this test, carried on on two farms only, the question of the relation between the analysis of roots and their feeding value was taken up for further investigation.

A new set of experiments was therefore carried out in 1890–92 on three large farms in 7 series, with 229 pigs arranged in 41 groups, in order to test the relative values of corn and various kinds of roots. These experiments were planned by Fjord, but after his death in January, 1891, they were carried out by F. Friis, his successor at the Laboratory for

Agricultural Research, attached to the Royal Agricultural College, Copenhagen.[1]

A preliminary series with 5 groups each of 5 pigs was carried out by Fjord from 2nd March to 10th May, 1890, with two kinds of roots, Eckendorf mangels and "Sucre blanc," a fodder sugar beet with a high percentage of sugar. The seed was supplied by the Society for Improving Cultivated Plants. All the groups had skim-milk and butter-milk in the same quantity. One group, A, had barley, the other groups had half the barley replaced by roots, group B having 8 lbs. of Eckendorf mangels for each lb. of barley, B_1 having only 6 lbs. of Eckendorf mangels for each lb. of barley, while groups D and D_1 had 6 lbs. and 4 lbs. respectively of Fodder Sugar Beets for each lb. of barley. These quantities were chosen because of the analyses, which showed the roots to contain:—

	Sugar. per cent.	Total Solids. per cent.
Eckendorf	8·93	12·71
Fodder Sugar Beet	13·80	19·86

The total average food for the whole period per pig in 10 days, as well as the average increases in weight per pig in 10 days, were as follows:—

Group	Barley.	Roots.	Milk.	Average increase.
	lbs.	lbs.	lbs.	lbs.
A	19	none	125	8·2
B	9½	76 Eckend.	125	8·7
B_1	9½	57 „	125	7·7
D	9½	57 F. S. B.	125	9·0
D_1	9½	38 „	125	7·9

The average increases show that 8 lbs. of Eckendorf mangels and 6 lbs. of Fodder Sugar Beet had about the same feeding value, and that these quantities were more than equivalent to 1 lb. of barley; and that 6 lbs. of Eckendorf had about the same feeding value as 4 lbs. of Fodder Sugar Beet, but that these quantities were hardly equal to 1 lb. of barley. It is noteworthy that the contents of sugar and of total solids in F. S. B. was about 1½ times that of Eckendorf, and that in groups B_1 and

[1] 26th Report from the Laboratory for Agricultural Research, by F. Friis and P. V. F. Petersen, København, 1892.

D_1 the two kinds of roots replaced each other in the same proportion, 6 lbs. Eckendorf to 4 lbs. of F. S. B.

This led to the planning of more extended feeding experiments for the purpose of ascertaining whether, as a general rule, different kinds of roots in the food of pigs can replace each other in a proportion corresponding to their contents of nourishment (sugar and total solids or dry matter) as determined by chemical analyses. The seed required for growing the roots to be used for these experiments was also supplied by the above-named Society, and was sown in the spring of 1890 on the various farms where the experiments were to be carried out. The same was done in the spring of the next year. In the autumn of each year the roots were analysed, and from the analyses were calculated the quantity of each kind of roots to be given in place of 1 lb. of corn. The three kinds of roots tested were Eckendorf, Elvetham and Fodder Sugar Beet, and the analyses showed the following percentages of sugar and total solids (dry matter) for each of the two years:—

	Sugar.			Total solids.		
	Eckendorf.	Elvetham.	F. S. B.	Eckendorf.	Elvetham.	F. S. B.
1890	6·44	8·88	11·44	9·48	12·40	15·86
1891	7·75	8·94	11·25	12·02	13·42	17·06

The first year it was decided to give 8 lbs. of Eckendorf, 6½ lbs. of Elvetham and 5 lbs. of F. S. B. in place of 1 lb. of corn, as the contents of—

	Sugar.	Total solids.
In 8 lbs. of Eckendorf was	0·52 lbs. and	0·76 lbs.
„ 6½ „ Elvetham „	0·58 „ „	0·81 „
„ 5 „ F. S .B. „	0·57 „ „	0·79 „

In the second year the Eckendorf mangels were richer in sugar and total solids. Therefore only 7½ lbs. were used that year, containing 0·58 lb. of sugar and 0·90 lb. of total solids. Of the two other kinds the same quantity was used each year, the analyses being about the same each year.

(The dry matter in barley and rye is about 84 per cent. of the weight of the corn. The weight of dry matter in the above

quantities of roots is approximately the same as the weight of dry matter in one lb. of corn.)

The food supplied to the pigs in these experiments was barley, butter-milk and skim-milk, about half of the latter being replaced by whey in the second year. Group A had as usual the normal quantity of corn, in group B, C and D half of the corn was replaced by roots, B getting 8 (or 7½) lbs. of Eckendorf, C 6½ lbs. of Elvetham, and D 5 lbs. of F. S. B. for each 1 lb. of corn. Six series of feeding experiments were carried out, two on one farm, three on another, and one on a third. The average increases in lbs. per pig in 10 days were :—

Groups	A	B	C	D
	Corn.	Eckendorf.	Elvetham.	F. S. B.
On one farm 2 series, 67 and 71 . .	8·1	8·4	8·4	8·2
„ „ 3 „ 68, 69 and 70 .	9·0	8·5	8·7	8·5
„ „ 1 „ 72	9·2	7·6	7·4	8·0
Average for 3 farms . . .	8·8	8·2	8·2	8·2
„ „ 6 series . . .	8·7	8·3	8·4	8·3

There is the closest agreement between the average increases in groups B, C and D, proving that the quantities of the three kinds of roots, calculated from their chemical analyses, had, as expected, the same feeding value. It is, therefore, possible from the chemical analyses of roots to calculate what quantities of different kinds of roots can replace each other as food for pigs without altering the rate or increase in the weight of the pigs. As the sugar is generally 60 to 65 per cent. of the total solids, it is for all practical purposes sufficient to estimate the amount of total solids or dry matter, which is so much easier to estimate than the amount of sugar.

It seems as if the quantities of roots given were hardly equivalent to 1 lb. of corn, but that was chiefly due to series 72 on the one farm. Of the two other farms one points in favour of corn, the other in favour of roots.

As a general result these feeding trials have therefore proved that roots can be used as food for pigs, and can replace part of the corn, giving 6 to 8 lbs. of mangels for 1 lb. of corn, according to the analyses of the mangels, and that various kinds or

strains of roots have a feeding value proportional to their contents of total solids.

During these same years Fjord had also carried out feeding experiments with milch cows. The first question to be solved was one which had for several years been much discussed among farmers: will an addition of a quantity of roots to the normal food for cows result in a greater yield of milk, will it affect the richness of the milk, and will it have any other effect on the cows? [1]

In 1884–85 some preliminary tests were made, which seemed to indicate that if sufficiently large groups of cows could be selected from very large herds, so that the different groups were as far as possible alike in all respects, it might be possible to get reliable results by working on similar lines to those followed in Fjord's feeding experiments with pigs. The first experiment with cows was carried out during the winter of 1887–88 on five large farms or estates each having a herd of 100 to 200 cows in milk. On three of the farms three groups were formed with 12, 10 and 10 cows in each group; on two farms it was found possible to get only two groups, having 12 cows each on the one farm and 13 cows each on the other. During a period of preparation, lasting from 3 to 5 weeks, a number of cows were selected on each farm, which, if placed in groups, would form groups so nearly alike in average age, weight, length of time since calving, yield of milk, and percentage of fat in the milk, that if fed alike they would also produce alike, both as to quantity and quality of milk. During this period of preparation the cows were all fed alike, and their yield of milk and quality of milk were tested daily. Only cows which had calved at least twice were selected. By changing the cows about and leaving out unsuitable cows the groups were at last finally selected for the feeding experiments. During a period of transition of 10 days their food was gradually changed to that which was to be given during the time of the feeding trial proper, which lasted during six periods of 10 days each.

The full scheme was worked out only on the three farms with three groups of cows. All three groups were to be fed with

[1] N. J. Fjord, "26 Beretning om Forsøg," København, 1888.

the fodder usually given on the farms, consisting of a certain weight of "concentrates" (*i.e.* corn, bran, and oil-cakes) and of hay, and as much straw as the cows cared to eat. But the quantity of straw consumed by each group was found by weighing the quantity given and the quantity left. This formed the food of one group on each farm, called C (for concentrates). Another group had the same food with an addition of 36 lbs. of mangels. This group was called M. The third group had the same food as C with an addition of 36 lbs. of turnips, and was called T. On each of the two farms with only two groups, one group was a C group. The other group on one farm had an addition of 24 lbs. of mangels (was an M group) and on the other farm an addition of 24 lbs. of turnips (a T group). These smaller quantities of roots were given at the wish of the farmers, such being the usual practice on these farms.

On one of the three farms, where the whole scheme was worked, the average daily fodder per cow for the C group consisted of:—

Palm kernel cake	1·5 lbs.
Rape cake	1·0 „
Bran	2·0 „
Crushed barley and oats	3·5 „
Clover hay	6·7 „ [1]
and Straw	*ad lib.*

The groups M and T on that farm had the same food, with an addition of 36 lbs. of mangels or turnips.

A similar mixed food was given on the other farms.

Before giving the average results for the different farms, it will be useful to examine in detail the results for each of the 10 days' periods on one farm during the periods of preparation, transition and experiment proper. We will take the records of the yield of milk and of the percentage of fat in the milk. The quantities of milk represent the average daily yield in lbs. of 10 cows, or the average yield of one cow in 10 days. As the milk of each cow was weighed daily morning and evening, each of the figures in the following table is the result of two hundred separate weighings:—

[1] Namely, 8 lbs. daily during the first 20 days and 6 lbs. during the last 40 days.

MILK YIELD ON ONE FARM.

Groups	Daily yield of 10 cows.			Percentage of fat.		
	C	M	T	C	M	T
	lbs.	lbs.	lbs.			
Period of preparation—						
Jan 1 to 11	245	248	247	—	—	—
„ 13 to 18	238	240	248	3·11	3·20	3·19
„ 18 to 28	237	238	241	3·15	3·19	3·25
Period of transition—						
Jan. 28 to Feb. 7 . .	224	237	234	3·34	3·31	3·38
Period of experiment—						
Feb. 7 to 17 . . .	218	240	234	3·37	3·35	3·38
„ 17 to 27 . . .	214	232	229	3·25	3·24	3·34
„ 27 to March 8 .	206	222	226	3·17	3·19	3·27
March 8 to 18 . . .	197	215	215	3·27	3·33	3·37
„ 18 to 28 . . .	193	213	213	3·16	3·28	3·34
„ 28 to April 7 . .	192	212	208	3·18	3·32	3·31
Average for experiment .	203	222	221	3·23	3·29	3·34

The figures for the last ten days of the time of preparation show how far the three groups were alike as to yield of milk. To get them exactly alike is, of course, an impossibility. If we look at the average percentage of fat for the whole time of the experiment (in the last line on the right of the table), it appears that group T had a slightly fatter milk than the other groups; but as that was also the case during the last ten days of the time of preparation, this difference could not properly be ascribed to the different feeding during the experiment. On the other hand, there is a clear indication (in the last line on the left) that the addition of roots to the fodder of groups M and T has resulted in a larger yield of milk. The average figures in the last line show that the cows in these groups yielded about 2 lbs. of milk more per day than those in group C. More will be said on this subject when we consider the average results obtained on all the farms.

But before leaving the above table it would be worth while to point out how easily a farmer might be misled by a wrongly conducted feeding experiment. During the time of preparation all cows had 18 lbs. of roots a day. At the transition to the period of experiment proper these 18 lbs. of roots were gradually

omitted from the food of group C, while 18 lbs. of roots were added to the food of groups M and T. If one were trying to find the result of this addition of 18 lbs. of roots to the food of groups M and T by comparing the amount of milk yielded by these groups during the time of preparation with the yield during the time of experiment, one might be led to the conclusion that the addition had had no effect whatever, or even an adverse effect. The table shows that the yield of milk is gradually reduced for both groups, but this is simply due to the natural circumstance that the yield diminishes with the increasing distance from time of calving. Probably such experiences by practical farmers may have led them to the conclusion asserted by several, that roots have no effect on the yield of milk. To arrive at a true conclusion it is, therefore, necessary, as was done in all these feeding experiments by N. J. Fjord, to compare equal groups of animals fed differently, but concurrently, during the same periods. Or, in the present case, the effect of giving an addition of roots must be deduced by comparing the yields of groups M and T with that of group C during the same periods, or in other words, by comparing the figures horizontally, not vertically.

We will now examine the analyses of the milk from the different groups, taking the averages of the groups on all the three farms. Samples of milk were taken morning and evening, but as the times of milking had been purposely arranged to be just twelve hours distant from each other, the quantity and quality of the morning and evening milk were so nearly alike that it is sufficient to deal with the analyses of the mixed morning and evening milk. The average composition of the milk of the three groups, C, M and T, was calculated for each farm for the whole 60 days of the experiment proper, and from that again the averages for all three farms. It is these averages for all three farms which are given in the following table. They deal with the milk of 96 cows during 60 days. Each figure, therefore, represents a very large number of analyses, but a study of the detailed tables from which these averages have been calculated shows that the same result which appears from the table below is

indicated by the figures for each 10 days' period on each farm.

AVERAGES OF CHEMICAL ANALYSES OF THE MILK FROM THE DIFFERENT GROUPS ON THREE FARMS.

Groups	C	M	T
Fat	3·18	3·18	3·18
Albuminoids . . .	3.05	3·08	3·09
Sugar of milk . . .	4·79	4·90	4·80
Ash	0·79	0·79	0·77
Water	88·19	88·05	88·16

Very similar results were obtained by the experiments on the two other farms on which only two groups were tested, C and M, or C and T.

The result of the inquiry into the effect on the composition of milk produced by giving an addition of 36 (or 24) lbs. of mangels or turnips to an ordinary and sufficient food is, therefore, that the addition of roots has had no effect at all on the composition of the milk. The idea, entertained at that time by many Danish farmers, that the addition of roots, while increasing the quantity of milk, resulted in a more watery and less rich milk, milk with a smaller proportion of fat, is clearly proved to be fallacious. The milk yielded by the different groups, fed differently, was practically quite alike, not only as regards the contents of fat, but also as regards the contents of the other constituents of the milk; the milk yielded by the cows fed on roots was certainly not more watery than the milk yielded by the cows which had no roots.

Quite a different answer was obtained to the question whether this addition of roots had any effect on the quantity of milk yielded. On account of the fact previously noted, and well known to all dairy farmers, that the quantity of milk gradually decreases with the increasing distance from the time of calving, it is necessary to consider the quantities of milk yielded both during the time of preparation, when all cows were fed alike, and during the time of experiment, when the cows in the different groups were fed differently. Dealing, as

before, with the averages for the three farms, the result appears from the following table :—

AVERAGE QUANTITY OF MILK YIELDED BY TEN COWS DAILY.

Groups	C	M	T
Time of preparation—	lbs.	lbs.	lbs.
1st farm, 16 days 2nd „ 15 „ 3rd „ 20 „	245	247	244
Time of experiment—			
1st farm, 70 days 2nd „ 60 „ 3rd „ 60 „	203·7	230	216·3

When a correction is made for the slight difference in yield during the time of preparation, it is found, as a result of giving an addition of 36 lbs. of roots daily per cow, that group M gave 24 lbs. more milk for 10 cows daily, and that group T gave 14 lbs. more milk, when comparing in both cases with the yield of group C.

As straw was given *ab lib.*, it is possible that a different consumption of straw may have had an effect on the yield of milk. The quantities of straw consumed daily by 10 cows averaged during the time of experiment:—

For Groups	C	M	T
	lbs.	lbs.	lbs.
On the 1st farm . . .	136	113	130
„ 2nd „ . . .	113	120	117
„ 3rd „ . . .	25	25	23

The small amount of straw consumed on the third farm was due to the large amount of hay (equal for all groups) fed on that farm. It will be seen that the addition of mangels on the first farm seems to have caused a saving in straw, but otherwise there is no great difference in the amount of straw consumed.

It is necessary, however, to notice also what effect the addition of roots had on the weight of the cows. That appears from the following table, giving the average weight of the cows in each group on each farm at the beginning and at the end

of the experiment. The average increases for the three farms together are also given, and the differences between the increase of the cows which had roots (M and T) and those which had none (C).

AVERAGE WEIGHT AND INCREASE PER COW.

Group	C	M	T
Average weight on the first farm—	lbs.[1]	lbs.[1]	lbs.[1]
At the beginning	878	887	897
At the end	916	955	945
Average weight on the second farm—			
At the beginning	858	873	898
At the end	851	902	905
Average weight on the third farm—			
At the beginning	830	849	820
At the end	822	870	841
Average increase for the three farms .	8	39	25
Increase above that of group C . . .	0	31	17

The addition of roots to the food has, therefore, resulted in a larger increase in the weight of the cows. Like the increase in the yield of milk, which was about double as large for group M as for group T, so also is the increase of the cows caused by the roots nearly double as large for group M as for group T. This result, that 36 lbs. of mangels had a greater effect than 36 lbs. of turnips, is in full agreement with the analyses of the two kinds of roots, which showed that on an average the mangels contained 8·00 per cent. of sugar and the turnips only 3·37 per cent.; the mangels had 13·62 per cent. of total solids, the turnips only 7·96 per cent.

The result of giving an addition of 36 lbs. of roots per day to the food of milch cows may, therefore, be summarised as follows:—

No difference whatever in the composition or richness of the milk.

A larger yield of milk, and larger for mangels than for turnips.

[1] Danish pounds, being 10 per cent. larger than English lbs.

A larger increase in the weight of the cows, and larger for mangels than for turnips.[1]

Fjord, who considered that in this experiment he was merely feeling his way, concluded, however, that the results indicated the possibility of obtaining reliable results by further feeding trials on the same lines, if farmers with large herds were willing to co-operate and again to place their herds, byres, and dairies at his disposal. This he found they were quite willing to do, and the following year, from January to April, 1889, he conducted an extensive series of feeding trials on five large farms or estates. On four of these, four groups of cows were formed on each farm, each group comprising 10 cows (on one farm only 9 cows in each group), and on one farm he had three groups with 10 cows in each, making altogether 186 cows arranged in 19 groups.[2] The questions to be solved were somewhat different from those of the previous year. It was customary on many farms to give the cows more concentrates when economy had to be exercised with the roots towards the end of the season, or when the roots had been all used up, and it was taught in the Agricultural School at Tune, and also in a book published by the principal of that school, that 10 lbs. of mangels and 12½ lbs. of turnips could replace 1 lb. of concentrates, either corn or oil cake. It was therefore decided to proceed as follows. Keeping within the limits of the mixed fodder as generally used on the different farms, one group on each farm was to be fed on concentrates, with a fixed quantity of hay and with straw *ad lib.*, but it was to have rather more concentrates than during the experiment of the previous year. This was the C group. The food of another group was changed by giving 2 lbs. less of concentrates per cow per day and giving instead 20 lbs. of mangels on some of the farms, and 24 lbs. of turnips on the other farms. These groups were called C^2. Still another group on each farm had 4 lbs. of concentrates less than group C, but instead of these 4 lbs. each cow had 40 lbs. of mangels or 48 lbs. of turnips. These groups were called C^4. On the four farms where a fourth group was formed,

[1] The addition of only 24 lbs. of roots to the food of the cows on the two other farms had, naturally, a lesser effect, and had indeed on one of them no visible effect.

[2] N. J. Fjord, "28 Beretning om Forsøg," København, 1889.

this group had the same amount of concentrates as group C, and besides this each cow had an addition of 40 lbs. of mangels or 48 lbs. of turnips. These groups, called C + R (concentrates + roots), were consequently fed more liberally than the other groups. Groups C and C+R stand in the same relation to one another as the groups C and M (or T) in the previous year, but they had a larger amount of food than the groups in 1888. The duration of the feeding experiment proper, divided as usual into periods of 10 days, was in 1889 60 or 70 days. As in previous feeding trials, it was decided by drawing lots which food was to be given to each of the groups formed during the period of preparation. A table of the mixed fodder given daily per cow on two of the farms is given here as an illustration :—

Groups	C	C^2	C^4	C+R
On the first farm—	lbs.	lbs.	lbs.	lbs.
Corn and bran	8	6	4	8
Oil-cake	1	1	1	1
Total concentrates	9	7	5	9
Mangels	0	20	40	40
Hay	5	5	5	5
Straw consumed	13	13	13	12
On the third farm—				
Corn and bran	8·5	6·5	4·5	8·5
Oil-cake	1·5	1·5	1·5	1·5
Total concentrates	10	8	6	10
Turnips	0	24	48	48
Hay	14	14	14	14
Straw consumed	5	5	5	3

On the second farm the 2 (or 4) lbs. of concentrates replaced by roots were taken in equal proportion from corn and oil cakes. The food given to groups C^2 and C^4 represents the general feeding on the farms, so long as the farmers had roots enough.

The scheme in 1889 also differed from that of 1888 in this respect, that while in 1888 the observations ceased with the end of the period of experiment proper, when the cows were fed differently, in 1889 the observations were continued for some

time after this, during which time the cows were again all fed alike. This was done for the purpose of finding out whether the differences in yield observed during the time of different feeding would disappear and the various groups yield alike when they were again fed alike.

The composition of the milk, according to the full analysis, and particularly its contents of fat, were so nearly alike throughout that it would not seem justifiable to ascribe the small differences observed to the effect of the different feeding. It will be sufficient in this naturally very abridged description to give the average percentages of fat in the milk per group for the four farms with four groups each :—

Groups	C	C^2	C^4	C+R
During time of preparation . .	3·36	3·33	3·32	3·37
During time of experiment . .	3·20	3·18	3·12	3·22
In after-time	3·18	3·21	3·19	3·25

The average quantities of milk yielded per cow in 10 days (or by 10 cows in one day) per group for the four farms were as follows :—

Groups	C	C^2	C^4	C+R
	lbs.	lbs.	lbs.	lbs.
During time of preparation . .	244	246	244	246
During time of experiment . .	214	210	212	230
In after-time	186	183	181	191

The average weights of the cows and the average increases in weight per cow in ten days during the time of different feeding and afterwards are given in the next table :—

Groups	C	C^2	C^4	C+R
	lbs.	lbs.	lbs.	lbs.
Weight of cows	919	906	916	919
Increase per cow in ten days—				
During the experiment proper	0·8	1·7	1·8	4·2
In after-time	1·4	0·9	1·3	− 0·8[1]

[1] Loss of weight.

The average quantities of straw consumed per cow in ten days during the experiment proper on the four farms were:—

Groups	C	C^2	C^4	C+R
——	lbs. 115	lbs. 115	lbs. 113	lbs. 98

Let us first compare the figures for groups C, C^2 and C^4. The groups were supposed to be equally well fed, but 2 or 4 lbs. of concentrates were replaced by 20 (24) or 40 (48) lbs. of roots. There is a little difference in the yields of milk during the time of experiment (214, 210, 212) in favour of group C. There is also a slight difference in the increases of weight (0·8, 1·7, 1·8), but this is in favour of the roots. Group C^4 has consumed a trifle less straw. Taking all this together, it would be very difficult, or rather, impossible, to decide which of the different ways of feeding has produced the best, that is, the most economical, result. That is the same as saying that the experiment with these sets of three groups has proved that practically speaking the 20 lbs. of mangels or 24 lbs. of turnips have had the same feeding value as the 2 lbs. of concentrates, and that 40 lbs. of mangels or 48 lbs. of turnips have been a full equivalent for 4 lbs. of concentrates.

A closer scrutiny of the records from the different farms, which is beyond the scope of this book, gave some indications that the composition of the fodder, particularly the quantity of oil-cake in a fodder with a large amount of roots, had some slight influence on the yield. In the following years' feeding experiments this question was investigated more closely. Another question, namely, the relative feeding values of corn and oil-cake has also been inquired into, and it was found that most oil-cakes have a greater feeding value than the same weight of corn. I mention these things merely to emphasise the fact that the results of the feeding experiments described above form only the beginning of a long series, and must not, therefore, be taken as final. Generally speaking the results then obtained still hold good. The first year's feeding experiments with pigs and cows gave Danish farmers the answer to their questions about the use of roots as food for animals,

and that is the subject which concerns us in this connection. A full description of the results of the Danish feeding experiments must be sought elsewhere.

We have yet to compare the groups C and C+R from the feeding experiments in 1889. The particulars are given in the tables on preceding pages. The question was whether an addition of roots to an otherwise liberal ration of concentrates, hay, and straw had any effect on the yield. In a later publication [1] a summary is given of all the experiments made to solve this question, on six farms through three years (1888, 1889 and 1890), including the experiments in 1889 above referred to. It would, therefore, seem better to give some extracts from that summary, which is naturally more comprehensive. The following figures are calculated from a very large number of analyses and weighings in connection with the feeding of 540 cows:—

SUMMARY OF THREE YEARS' FEEDING TRIALS TO TEST THE EFFECT OF AN ADDITION OF MANGELS TO THE FOOD OF MILCH COWS.

Group	C	C+R
Percentages of fat—		
During time of preparation	3·20	3·20
During time of experiment	3·22	3 22
In after-time	3·23	3·34
Yield of milk per cow in ten days—	lbs.	lbs.
During time of preparation	236	237
During time of experiment	205	227
In after-time	194	190
Increase in weight per cow in ten days—	lbs.	lbs.
During time of experiment	1·6	5·4
In after-time	1·1	—2·4 [2]
Total . . .	2·7	3·0
	lbs.	lbs.
Straw consumed	137	109

The composition of the milk was not affected during the time of experiment, but there is an indication that the addition of

[1] 34th Report from the Laboratory for Agricultural Research, Copenhagen, 1895.

[2] Decrease in weight.

roots tended to hinder a slight increase in the percentage of fat, which appeared when the cows were afterwards put on the same feeding for all groups. The addition of mangels clearly increased the yield of milk, from 205 to 227 lbs. per cow in ten days, and also caused a larger increase in the weight of the cows, and effected a saving in the amount of straw consumed. In the after-time group C+R lost in weight. Probably there is some connection between this loss of weight and the increase in the proportion of fat in the milk during the same time.

The effect of adding mangels to the food, calculated per 100 lbs. of mangels, taking the average of all six farms during all three years, was per cow per day:—

to increase the yield of milk by . . .	6·3 lbs.
to increase the weight per cow by . .	1·1 ,,
to reduce the straw consumed by . .	7·0 ,,

Similarly, it was found that the effect of adding 125 lbs. of turnips was per cow per day:—

to increase the yield of milk by . . .	3·0 lbs.
to increase the weight per cow by . .	0·7 ,,
to reduce the straw consumed by . .	1·0 ,,

The smaller effect of adding turnips, even 125 lbs. against 100 lbs. of mangels, agrees very well with the average analyses of the two kinds of roots used:—

	Sugar. per cent.	Total solids. per cent.
Mangels	7·54	12·96
Turnips	3·28	8·88

The feeding trials conducted by N. J. Fjord, at the repeated request of leading Danish farmers and with their active co-operation, had then, in the course of a few years, given definite answers to the questions as to the feeding value of roots. They had shown that roots had a very considerable value; that roots could replace corn and oil-cake in the food of both cows and pigs without changing their growth or the production of milk; that the addition of roots to the food increased the milk yield of cows and made them lay on flesh at the same time; and that the larger yield of milk produced by giving roots was not caused by a greater proportion of water in the milk, but

that the larger yield was of milk of the same richness as the milk produced without the addition of roots. On weighing in some of the experiments the amount of water drunk by the cows, it was found that the cows fed on roots drank less water, and that this decrease was about equivalent to the amount of water contained in the roots they consumed. It has, further, been clearly established by these experiments that different varieties of roots have different feeding values, according to their varying contents of dry matter or total solids; that the different strains within the same variety have different contents of dry matter and, therefore, different feeding values; that, consequently, some strains are more profitable to grow than others. As a general conclusion it has been proved that 1 lb. of dry matter in roots has the same feeding value as 1 lb. of corn, or is equivalent to "one unit of food." In the 30th Report (1895, p. 19) it was found that, pound for pound, the dry matter in mangels and in carrots had the same feeding value for pigs; in the 42nd Report (1899, p. 23) it was found that, pound for pound, the dry matter in Yellow Tankard and Bullock turnips and in Bangholm swedes had the same feeding value for pigs as the dry matter in Eckendorf mangels; in the 53rd Report (1902, pp. 7 and 11) it was found that 1 lb. of dry matter in mangels had the same feeding value for milch cows as 1 lb. of corn when fed in the usual mixed fodder with a nitrogen ratio varying from 1·5 to 1·9; in the 55th Report (1904, p. 136) it was found that 1 lb. of dry matter in Barres and Elvetham mangels and in swedes had the same feeding value as 1 lb. of corn when fed to milch cows; and in the 89th Report (1915, p. 16) it was again proved that the dry matter in mangels and in swedes had the same feeding value, pound for pound, when fed to milch cows.

In the 55th Report (p. 137) it was recommended to devote to the cultivation of roots one-third of the acreage under fodder crops for feeding the cattle during the winter.

These feeding trials had been planned and conducted on farms in different parts of the country after full consultation with the farmers, and the published reports had been written so carefully and yet in such simple language that the results were easily assimilated, and gained the complete confidence of

Danish farmers. "I am doing no more than making systematic records of the experiences of practical farmers," was a frequent expression of Fjord's, when speaking of this important, yes, epoch-making, work, which he initiated and which has been carried on after his death in the same spirit. And as Danish farmers, both on large and on small farms, were able to and eager to profit by any reliable teaching of how to improve their farming methods and their feeding of live stock, it is little wonder that Fjord's feeding trials with roots soon resulted in an increased cultivation of roots. The acreage under roots for feeding, viz. mangels, swedes, and turnips, was :—

1888	95,000 acres
1896	180,000 „
1901	330,000 „
1907	565,000 „
1912	627,000 „
1919	678,000 „

The accepted fact that 1 lb. of solids in roots was equal in feeding value to 1 lb. of corn when fed to cattle enabled a comparison to be made between the production of food-stuffs when growing corn and when growing roots. With a crop of 38 bushels of barley to the acre one acre will produce 1900 lbs. of corn. With a crop of 19 tons of swedes to the acre one acre will produce 42·560 lbs. of swedes with, say, 12 per cent. of solids, or 5107 lbs. of solids. These were the average yields in Denmark during the years 1909–1913.[1] By growing barley the farmer will therefore produce 1900 lbs. of food-stuff per acre, while by growing swedes he will produce 5100 lbs. of equally good food-stuff, or more than $2\frac{1}{2}$ times as much. The official Danish Statistics [2] estimate the average production of food-stuff in Denmark during the years 1908–14 to have been :—

When growing corn	20·2 cwts. per acre
When growing roots	38·7 „ „

This consideration was a very great inducement to farmers to extend the acreage under roots. There is not the slightest doubt that the large root-crops enabled Denmark to pull

[1] "Co-operation in Danish Agriculture," p. 165.

[2] Statistiske Meddelelser, "Høsten i Danmark, 1908–14," 4 R. 58 Bd. P. 1 København, 1919, p. 19.

through the difficult time during the war, when the import of feeding-stuffs ceased, in a manner which would otherwise have been quite impossible.

A comparison of the relative importance of the root-crop in Denmark and Great Britain during last century was given in the beginning of this chapter. It will be worth while to see how the root-crops in the two countries compare now, and how they have developed during the war, quoting the official statistics of both countries. In Great Britain the acreage under mangels, swedes, and turnips was in 1912 13·6 per cent. of the total arable land, in 1918 it was considerably less, viz. 10·8 per cent. In Denmark it was in 1912 relatively less than what it was in Great Britain, viz. 10·2 per cent., but it increased during the war, and was in 1918 11·1 per cent. If we calculate the proportion between the acreage under mangels, swedes, and turnips and the total acreage under crops and grass, the relatively great importance of the root-crop in Danish Agriculture is more conspicuous.

The acreage under mangels, swedes, and turnips as percentage of the total acreage under crops and grass was :—

	1912. per cent.	1918. per cent.
In Denmark	8·7	9·7
In Great Britain . . .	6·3	5·4

CHAPTER II

IMPROVED STRAINS OF ROOTS, SELECTED BY COMPARATIVE CULTIVATIONS AT THE EXPERIMENTAL STATIONS OF THE STATE

SEVERAL years before Fjord began teaching Danish farmers the true feeding value of roots other public-spirited men had done some very important work to improve the growing of roots and other farm crops, and to encourage and improve the growing of seed. For many years farmers had been in the habit of themselves producing some of the seed they needed, but without any system. Of root seed, however, foreign seeds were mostly used, but often of unsatisfactory quality, of low germination, and sometimes very impure. As early as 1860 Frantz Wendt, a gardener, of Roskilde, encouraged farmers to grow seed, more especially of roots and forage crops, and to select the best plants from which to take seed. He pointed out that there was very much adulterated imported seed in the market, and maintained that home-grown seed, harvested fully ripe from plants well cultivated in rich soil, was better than even the best imported seed. It is interesting to note that at that early date he recommended testing seed by sowing a counted number of seeds in shallow pans; 75 per cent. ought to germinate.[1] The first seed-testing station in the world was founded nine years later, in Tharand, in Saxony, by Nobbe, and in 1871 E. Møller-Holst, editor of the oldest Danish weekly agricultural paper, *Ugeskrift for Landmænd*, started his "Danish Field Seed Control" in Copenhagen. As the station in Tharand no longer exists, the Danish Seed Testing Station is the oldest in the world, and is the one at which at present the greatest number of analyses are made. The effect of this station in improving

[1] Fr. Wendt, "Om Sædefrø," *Ugeskrift for Landmænd*, 1860, p. 235.

the seed on the market is best illustrated by the fact that while in 1871 samples of clover and grass seeds showed no more than 25 per cent. of pure seed able to germinate, similar samples in 1889, at the death of the founder of the station, showed 80 per cent., with a marked improvement in the varieties used. The Seed Testing Station, originally a private venture, had proved so valuable an aid to farmers and to honest seed merchants that it was taken over by the State in 1891, since when it has developed to such an extent that the 1600 samples tested in 1891 had increased to 24,400 samples in 1918–19.

When Møller-Holst began his work of testing the genuineness, purity, germination, and even the origin of samples of agricultural seed, he offered to Danish farmers just that opportunity which some far-seeing men had been wanting. One of these, like not a few rural reformers in Denmark, came from the teaching profession. Chr. P. Jacobsen, born in 1841 in the Danish North Slesvig, and in 1864, when Denmark lost Slesvig, transferred to a school in Thisted (the place where in 1866 the Rochdale co-operative system was introduced), took an intelligent interest in agriculture. In 1868 he started a weekly paper, *Landmands-Blade,* and wrote a long series of articles, in which, among many other subjects, he dealt with the greatly neglected state of the trade in agricultural seed, which he characterised as " the lawlessness of ignorance." In 1872 he was joined by another teacher, J. L. Jensen, whose monograph on the potato disease (*Phytophthora infestans*) in 1882 was awarded a gold medal by La Société Nationale d'Agriculture de France, and by the gardener, Fr. Wendt. These three men issued an invitation to farmers to participate in the joint purchase of analysed seed and seed corn, in order to secure to farmers seed of the best quality, of suitable origin, and at reasonable prices. So successful was the appeal that 2000 farmers joined, and 250,000 lbs. of seed of guaranteed purity and germination were supplied in 1873. The seed firm of Andr. Schmidt joined them two years later, and the three original founders, with Messrs. Schmidt and Carl Maag, founded an " Office for the Joint Purchase of Analysed Seed," or " Markfrøkontoret," This firm has been a pioneer in the seed trade. Not only has it reformed the trade, but also fostered

the cultivation of seed by sending out stock seed and buying the seed crop of growers, by carrying out experiments, by issuing an annual publication, and in several other ways. It was the first business in the world which offered farmers seed of guaranteed analysis. In 1900 "Markfrøkontoret" was turned into a joint stock company called "Trifolium," [1] which is still among the leading seed firms in Denmark. Jacobsen's endeavour to improve the cultivation of agricultural seed found vent in another direction. In 1876, in conjunction with Møller-Holst, Fr. Wendt, and others, he formed a "Society for the Production of Home-Grown Seed," managed by a committee, on which were three scientific botanists, three seed merchants, and nine farmers.[2] The aims of the Society, which in 1880 changed its name to the "Society for Improving Cultivated Plants," were to encourage the growing of seed by securing the best stock seed, and by assisting the trade in approved home-grown seed; to regulate and simplify the nomenclature of roots and other agricultural plants, and to do away with the many trade names for practically identical plants; to assist comparative experiments with roots and the growing of seed, particularly by small-holders; to arrange exhibitions, and so on.

An improved cultivation of roots was brought to the notice of Danish farmers from outside, and in two ways. One was the introduction of the growing of sugar-beet. The seed was bought in Germany, and the advanced method of cultivation practised there was taught the farmers who grew sugar-beet on contract with the beet sugar factories. The other was the experience of Danish estate owners, who visited Scotland and England and studied the cultivation of roots, and even helped young agricultural graduates to go there to study, in order to teach the farmers what they themselves had learnt. In 1876 a young gardener, M. P. Andersen, had studied seed culture in Scotland and England (Lincolnshire). He published his report in 1879,[3] in which he explained how the large seed merchants in Great Britain produced stock seed by selecting in the autumn

[1] "Dansk Frøavls Kompagni og Markfrøkontoret Trifolium" is the full title of the firm.

[2] "Om Landbrugets Kulturplanter," København, 1879.

[3] "Tidsskrift for Landøkonomi," København, 1879, p. 283.

the best shaped and most typical of the spring-sown roots, wintering these in pits and planting them out in the spring for growing seed ; that the firms never sold of this stock seed, but supplied it to growers, and only one variety to each grower, in order to avoid crossing ; that this stock seed was sown late in July, covered in the winter, and planted out in spring for seed growing ; the seed so produced formed the trade seed which the firms sold to farmers or dealers. Andersen recommended the same system of seed growing to be introduced in Denmark, and pointed out that a leading man was required who could improve the stock seed—by selection, cross-breeding, or other means—and supply it to growers, principally small-holders. Buyers of seed would thereby get a guarantee of good quality, production would be regulated, and seed growers would be secured a market for their seed. The Society for Improving Cultivated Plants took this matter up, and several farmers and small-holders began to produce stock seed and to improve their particular strains.

In 1885 the Society somewhat altered its aim inasmuch as the encouragement of the production of seed took a second place. The chief work henceforth was to carry out comparative cultivations of various field plants, chiefly roots, in order to find which varieties and which individual strains within the variety gave the greatest yield. It was very soon decided that the aim should be to find those strains which gave the greatest yield of solids per acre.[1] Chr. P. Jacobsen (Markfrøkontoret) had already started such work, and had engaged L. Helweg, a young horticultural graduate from the Royal Agricultural College, to superintend and report on these trials. In March, 1886, the Society, co-operating with Markfrøkontoret, engaged Helweg to undertake this work for the Society, and the same year he published his first report [2] on the cultivation of roots. Since then we have had a report from his hand every year. He arrived at the preliminary conclusions that it was necessary to observe not only the yield of roots per acre, but also the contents of dry matter or solids in the roots ; that different varieties of roots had a different contents of solids, and that this varied

[1] "Om Landbrugets Kulturplanter," 1885, p. 178.
[2] Ibid., 1887, p. 129.

even in the different strains within the variety; that the power of producing more or less solids in the roots under given circumstances belonged to the strain, and was inherited through the seed; that small roots had a larger percentage contents of solids than large roots; that different kinds of soil had an influence on the contents but similarly on the different strains, that is to say, if a soil lowered the contents of one kind of root it influenced them all in the same way, so that the relative merit of the different kinds in respect of yield remained the same, whether grown on one soil or another, but that this influence of the soil is different for mangels, turnips, and other kinds of roots; that the tendency to run to seed during the first year is a character of the strain and is inherited, and that this tendency will materialise the more readily the earlier the seed is sown, the better the field is manured, and the greater the distance between the rows and plants.[1] In his first report he mentioned that in 1885 he had compared home-grown seed and imported seed of seven different kinds of mangels, and had found that according to yield in cwts. of roots per acre the home-grown seed was considerably superior to the imported seed, except in the case of Wroxton, where the Scotch seed was better than the home-grown Danish.

In 1890 the Society hired five acres of land from the agricultural school at Lyngby, near Copenhagen, to be their experimental station, and appointed K. Hansen, an agricultural graduate, to carry out various experiments with cereals. The State gave the Society a grant of £275 for each of the next three years, but in 1893 the Society found it impossible to carry on, and it was wound up. Its work was, however, considered so valuable that the State decided to take it over. The Experimental Station at Lyngby was bought by the State and largely extended, and Helweg and K. Hansen were engaged by the State.

A special series of comparative cultivations of roots was begun by Helweg in 1889, and has been continued with modifications till this present day. It is truly remarkable that from the very first he saw clearly the chief aim which has been kept in view ever since, and which will be pursued even when he will no

[1] "Om Landbrugets Kulturplanter," 1888, p. 113.

longer be able to superintend the work. In September, 1888, Helweg read a paper at the meeting of representatives of the Society for Improving Cultivated Plants, in which he proposed that the Society should arrange annual "Comparative Cultivation Tests" of seed of the different kinds of roots.[1] The purpose of these competitions was manifold. To a certain extent it may be said that Helweg aimed at finding which of the varieties of mangels, turnips, swedes, or carrots, was the best; for instance, whether Elvetham or Golden Tankard among the mangels, or whether Yellow Tankard or New Bronze Top among the turnips, yielded the most food-stuff, the largest amount of solids per acre. But the chief purpose was to obtain reliable information about the different strains of roots, of which seed were in the market, and to compare the home-grown seed with the imported seed. It was Helweg's aim from the beginning to encourage those seed growers who had good strains, and to induce those who worked with poor material to change it for the better strains, so as gradually to eliminate from the market seed of bad or inferior strains, and to get them replaced by seed from the best strains. The result would be to render the growing of roots more profitable to the farmers, and the farming industry more valuable to the country.

His proposal was very well received. In January, 1889, the Society issued its first invitation to Danish seed growers to send in, free of cost, samples of seed to be grown in competition with samples of seed from seed firms abroad. The samples of seed were divided so as to be grown two years in succession, and the results of the two years' growing were to be published annually (first time in 1891) without mentioning names of growers or firms. Five samples of Elvetham, ten of Barres, and five of the German variety Eckendorf were entered in 1889, besides turnips, carrots, and swedes of different varieties. As it is the method of investigation and the general results obtained which alone interest us here, I shall in the following pages deal mostly with the reports on mangels, but it should be understood that similar investigations with similar results were carried out with varieties of the other kinds of roots. During each of he following years samples were called in to be grown during that

[1] "Om Landbrugets Kulturplanter," København, 1890, p. 6.

and the following year, and every year from 1891 onwards a report was issued giving the result for two years. Every year three or four samples of the best seed to be obtained from seed merchants at home and abroad were sown for the sake of comparison along with the sample of the same varieties sent in by Danish seed growers.

The seeds were sown at first on various large farms, and every precaution was taken to have the roots grown under favourable conditions, the same for all samples. After some years' working according to this plan it was found necessary to have the samples grown on the Experimental Stations of the State, and from 1894 to 1899 the competitions were carried out on the four Experimental Stations then existing. When later on three more stations, besides three branch stations, were acquired by the State, these new stations also took their part in the work of these " Comparative Cultivations." It was considered necessary to work with greater accuracy than could be obtained by growing the samples on ordinary farms, because it was contemplated to publish, in connection with the experiments to be carried on after 1899, the names of the growers of seed of the best strains. Such publication would obviously have a very great influence on the trade in seed, and affect the economic interest of growers and merchants to a considerable extent. It was, therefore, necessary that the classification should be quite reliable. The samples grown between 1894 and 1899 were not procured by public invitation, as had been done hitherto, but certain merchants and some of the best growers of seed were privately asked to send in samples.

The chief object of the work during the first series, 1889–1899, might be said to be to evolve and to develop a reliable experimental technique. It was necessary to find out to what degree of accuracy the relative value of various strains could be estimated, for instance, on how many " parallel plots " on the field of each station a sample should be grown to give a reliable result, how to take a true average sample of a root crop, and how to estimate the amount of total solids in the sample, and so on. It was necessary that the work of preparing the soil, sowing, cultivation, and harvesting of the roots should be performed in exactly the same manner in each case, and this

could evidently be accomplished with far greater certainty when the work was done at the stations of the State under the guidance and personal supervision of trained and perfectly unbiassed experts in the service of the State. During the years 1894–99 much valuable experience was gained, which has since been further extended, and the experimental technique now acquired may fairly claim to lend to the published results a trustworthiness which could not easily be obtained by private work or by less elaborate methods.

In the year 1897 the State appointed a "State Committee on Plant Culture" ("Statens Planteavls Udvalg") to administer on behalf of the State the various experimental undertakings in connection with plant culture carried out at the cost of the State. The different Experimental Stations of the State, each with its own manager, are co-ordinated under this Central Committee. Helweg was appointed the Danish Government's Root Commissioner. The Comparative Cultivations of the various strains of roots are managed by a Sub-Committee under this State Committee, the Sub-Committee consisting of the managers of the Experimental Stations with Helweg as its Chairman. This Sub-Committee draws up a detailed scheme of the Comparative Cultivations, which is submitted to and passed by the Central Committee at its annual meetings.

It was decided that the different strains, of which seed was sent to the Comparative Cultivations, were to be judged according to their character and classified according to their yield. The question was therefore how to secure a reliable classification. The accuracy of the classification was measured by the agreement between the classifications at three stations. It was found impossible to find room at each station for growing all the different samples, but these were distributed in such a way that each set of samples was sown on at least three stations. In the later series, as the State has acquired more Experimental Stations, it has been possible to grow each sample on five stations. The number of parallel plots on which each sample was grown on each station was at first generally five to six, each being about $\frac{1}{400}$th part of an acre. In later years more plots were used, at present twelve on each station.

Although other characters of the roots were noted, the classification of the samples was based exclusively on the quantity of food-stuff (total solids) per acre produced. When the roots had been weighed and analysed and the number of cwts. of solids per acre calculated for each sample, the difference between the highest and the lowest yield was divided in three equal parts. Those samples that fell in the highest third were considered of Class I., those on the lowest third were Class III., the middle being Class II. This being done at each station the results were tabled as shown on the opposite page, the samples being placed in the order of the yield per acre calculated for each sample as the average of the yields found at the three stations.

It will be seen that the three best samples were placed in Class I. at each station, and that the two poorest ones were found to be in Class III. at each station, but that the positions of the others varied somewhat from station to station. This is partly unavoidable, as the different soil and climate at the various stations affected differently those samples which were on the border line between the classes. But it is also partly due to shortcomings in the technique, which was therefore gradually improved.

The present system of working is as follows: The various kinds of roots examined are distributed between the seven Experimental Stations and three branch stations in such a way that each kind is grown on at least five stations. At each station each sample is sown on at least twelve plots spread over the field, each plot being at least ten square yards. Each plot consists of two rows. The distance between the rows is 60 cm. (24 inches), the length of the rows may be from 10 to 12 m. (11 to 13 yards). The roots grown on the outside borders of the field are not used for the experiment, but are used as a kind of screen. When two strains of different growth, for instance, with small and large top, are in rows next to each other a screening row of each kind is interposed. These rows are not included in the experiment, but simply grown to make sure that the two rows of the strains forming part of the experiment are grown under normal conditions. The sketch on p. 40 of part of the field at Askov Experimental Station will show the arrangement. The field is divided into four quarters; each quarter is divided

——	Current Number of sample.	Dry matter in cwts. per acre.				Classification.		
		Tystofte.	Lyngby.	Askov.	Average.	Tystofte.	Lyngby.	Askov.
Class I.	3	70·5	64·4	68.1	67·7	1	1	1
	20	70·4	64·1	64·0	66·2	1	1	1
	6	67·7	65·1	61·8	64·9	1	1	1
	23	69·4	67·7	56·7	64·6	1	1	2
	5	68·2	61·8	61·9	64·0	1	2	1
	18	68·4	64·6	56·1	63·1	1	1	2
Class II.	9	67·6	61·3	57·6	62·1	1	2	2
	2	65·1	59·9	61·3	62·1	2	3	2
	10	64·8	59·3	60·5	61·7	2	3	2
	17	66·8	60·4	57·7	61·6	2	3	2
Class III.	8	61·8	60·1	57·4	59·8	3	3	2
	22	62·3	59·1	57·8	59·7	3	3	2
	11	65·0	59·1	49·6	58·2	2	3	3
	4	63·7	57·3	53·6	58·2	3	3	3
	21	63·3	58·0	53·3	58·2	3	3	3
Limits of yield for the classes at each station.	Class I.	70·5–67·6	67·5–64·1	68·1–61·6	——	——		
	II.	67·5–64·6	64·0–60·6	61·5–55·6				
	III.	64·5–61·5	60·5–57·0	55·5–49·6				

into three parts. Each of these parts has 54 rows, viz. two rows for each of 20 samples and 14 screening rows. Each sample is sown in each part of each quarter, or on 12 plots, but in a different place in each part. Each row is 12 m. (13 yards) long.

SKETCH OF PART OF FIELD G 9 AT ASKOV EXPERIMENTAL STATION, SHOWING THE ARRANGEMENT OF 20 SAMPLES OF MANGELS GROWN IN 1919.

1 m.	12 m.	1 m.	12 m.	1 m.	12 m.	1 m.
Ends of rows used as screens.	Screening row of sample No. 1 2 rows of sample No. 1 2 „ „ „ 2 2 „ „ „ 3 2 „ „ „ 4 Screening row of sample No. 4 Screening row of sample No. 5 2 rows of sample No. 5 2 „ „ „ 6 Screening row of sample No. 6 Screening row of sample No. 7 2 rows of sample No. 7 2 „ „ „ 8 and so on, until 2 rows of sample No. 19 2 „ „ „ 20 Screening row of sample No. 20	Ends of rows used as screens.	Screening row of sample No. 7 2 rows of sample No. 7 2 „ „ „ 8 and so on, until 2 rows of sample No. 20 Screening row of sample No. 20 Screening row of sample No. 1 2 rows of sample No. 1 2 „ „ „ 2 and so on, until 2 rows of sample No. 5 2 „ „ „ 6 Screening row of sample No. 6	Ends of rows used as screens.	Screening row of sample No. 15 2 rows of sample No. 15 2 „ „ „ 16 2 „ „ „ 17 2 „ „ „ 18 Screening row of sample No. 18 Screening row of sample No. 19 2 rows of sample No. 19 2 „ „ „ 20 Screening row of sample No. 20 Screening row of sample No. 1 2 rows of sample No. 1 2 „ „ „ 2 and so on, until 2 rows of sample No. 13 2 „ „ „ 14 Screening row of sample No. 14	Ends of rows used as screens.
	Screening row of sample No. 1 2 rows of sample No. 1 and so on		Screening row of sample No. 7 2 rows of sample No. 7 and so on		Screening row of sample No. 15 2 rows of sample No. 15 and so on	
	Third quarter	in	the same way.			
	Fourth quarter	in	the same way.			

The fields on which the roots are grown enter in the ordinary rotation of crops on the station. At harvest time the roots in screening rows, both lengthwise and crosswise, are thrown aside. The roots of the rows included in the experiment are then dealt with. The number of gaps in the row, and of plants run to

seed, are counted, the roots are then lifted and counted, the number of forked roots, etc., noted, and all the roots in each row are then weighed together. A character is given to each sample, indicating how far the roots approached to the shape typical for the variety. Finally an average sample is taken from each of the 20 samples, and the percentages of sugar and of total solids are estimated by chemical analysis.

To take an average sample of a quantity of roots for chemical analysis is by no means an easy matter, as the individual roots vary considerably in composition. To get a true average sample, is, of course, a necessary condition for obtaining a reliable analysis, and as more than 10,000 estimations of total solids in roots are made every year in Denmark, the matter has been closely looked into, and a method has been evolved, which has since been adopted in Sweden, Canada (McDonald College), Holland, and Germany.[1] If a result correct to the first decimal of the percentage is wanted, it has been found necessary to work on at least four samples of 50 roots each. The roots to be analysed should have the same average weight as the roots in the total stock. 500 roots are taken at random and weighed; 50 roots are taken from these 500, avoiding extreme sizes and shapes. The 50 roots are weighed, and by exchanging roots the weight of the 50 roots is regulated so as to be one tenth of the weight of the 500. The 50 roots are then carefully washed and left to dry.

When a sample of 50 roots has been picked out, the next thing is to obtain a true average sample of these 50 roots for a chemical analysis. Several methods have been proposed and used, but most of them fail to give a true average. In the eighties it was usual in Germany, by means of a revolving tooth-edged scraper, to scrape a wedge out of the root lengthwise reaching into the centre axis, the scraper removing the material in the form of a pulp, from which samples were taken for chemical analysis. But R. K. Kristensen has proved[2] that

[1] R. K. Kristensen, "Tørstofbestemmelse i Roer," *Tidsskrift for Planteavl*, 23 vol., København, 1916, p. 155. (Report written to the International Agricultural Institute in Rome.)

[2] R. K. Kristensen, "Tørstofbestemmelse i Roer," *Tidsskrift for Planteavl*, 18 vol., København, 1911, p. 96 (being the 55th Report of the State Committee on Plant Culture).

when the wedge is scraped out along the sides of the root where the rootlets sit a higher result is obtained than when scraping along the smooth parts. He found, for instance, along the rootlets 15·45 per cent. of solids, and along the smooth part of the same root 14·81 per cent. This, of course, applies only to roots of beets. He also found that the outside parts of a root contain more solids than the centre part, for instance, 14·49 as against 13·72 per cent. The not unusual method of cutting a cylinder out of a root by boring it through from side to side is therefore also unreliable. In the first place the cylindrical plug contains too large a proportion of the centre part; secondly, the result will vary according to whether the boring is done through the parts with the rootlets or through the smooth sides. As far back as 1893 Helweg [1] devised a method of getting a true average sample, containing the correct proportion of the outside and the inside parts, and of all sides of the root. His method, described in Kristensen's Report of 1916, and adopted in most countries where roots are frequently analysed, is as follows :—

The 50 roots of the sample are cut by means of a circular saw, 1 mm. ($\frac{1}{24}$ inch) wide and 45 cm. (17 to 18 inches) in diameter, fixed in an opening in a table. The teeth in the saw, 5 to the inch, must be sharp and turned out, so as to let the saw run free; they should be filed so as to run to a point on the side turned out, like a saw for cutting branches off trees. The roots are cut across perpendicularly on their axes, and the same distance, about $2\frac{1}{4}$ inches, is kept between the different cuts, independently of the size or shape of the root. The distance between the cuts should be so regulated that the amount of pulp produced by cutting 50 roots is about 1 kg. ($2\frac{1}{2}$ lbs.). A guide is fixed on the table at the side of the saw to regulate the distance between the cuts.

Underneath the saw is a zinc trough for receiving the pulp cut off by the saw. When the 50 roots have been cut, the pulp is carefully mixed, and 3 samples of 10 to 15 grammes weighed off for estimation of total solids and, if wanted, of sugar.

[1] L. Helweg, "Den kemiske Bestemmelse af Foderroens Næringsindhold," *Tidsskrift for Landbrugets Planteavl*, 5 vol., 1899, p. 178.

To estimate the amount of solids or dry matter in root pulp presents some difficulties, because the sugar is very easily decomposed when heated. It is, therefore, necessary to dry the sample at a lower temperature than usual in chemical analysis. Experiments by Prof. V. Storch,[1] R. K. Kristensen, and others have proved that all the water can be evaporated by drying at 85° C. (185° F.), that even at somewhat lower temperatures a true estimation of the dry matter can be made when drying a sufficiently long time or drying in vacuum, but that heating to temperatures above 85° C. causes a decomposition of the sugars, and more so in swedes than in mangels, noticeable by a brown colouration and a loss of weight beyond that due to the evaporation of the water.

After this description of the technique of these Comparative Cultivations as now practised we will revert to a consideration of the result of the work during the years from 1889 to 1899 inclusive.[2] The comparison was between the best strains only of each variety. At that time it was found that Barres (a yellow intermediate) was the best of the varieties of mangels grown in Denmark from Danish seed, Yellow Tankard the best of turnips, while Bronze Top or Bangholm were as good as any of the swedes, and Champion the best of carrots. These were also the kinds of roots most generally grown, and it is probable that this fact had a bearing on the result.

A comparison of varieties is, however, of limited value, inasmuch as the differences between various strains within a variety are often greater than the differences between the varieties. The chief and the most important result of these years' competitions was indeed to prove that the question: Which variety of roots shall be grown? is of very little importance compared to the question: Which strain shall I grow? Measured in price of corn, and taking 1 lb. of total solids of roots to be equal to 1 lb. of corn, as demonstrated by Fjord's feeding experiments with cows, it had been found that there could be a difference of £2 to £4 per acre in the values of the root crops when growing various strains of the same variety. This

[1] V. Storch, 58th Report from the Laboratory for Agricultural Research, 1905.

[2] Helweg's Report in *Tidsskrift for Landbrugets Planteavl*, 7 vol., Købennavn, 1901, p. 191.

difference was calculated at the then prices for corn. At the present prices the difference might be as much as £6 to £12.

In his final report on these years' competitions [1] Helweg summarises the result of comparing the different varieties by saying, that they point in the same direction as that in which the cattle breeding had developed, viz. that instead of hunting for new varieties all our efforts should be directed towards developing the best strains within the varieties which have already found general favour; and that "the greatest service which the growers of root seed can render farmers who grow roots is to reduce the number of varieties." Even at that time he found that "Denmark has a more uniform crop of roots than any other country." The aim should henceforth be to find the best strains within the few varieties now cultivated.

The competitions from 1889 to 1899 also aimed at getting information about the quality of the root seed grown in Denmark, and to assist the growers of seed by giving them reliable information which they could not obtain by their own exertions. In the competitions between seed from Danish growers and seed from Danish and foreign seed merchants the first generally came out well with regard both to the weight of roots per acre and to the amount of total solids per acre. It was, for instance, found, both for Barres and Elvetham, that several of the imported samples gave lower results than any sample from Danish seed growers. It was also clearly demonstrated, "how senseless it is that farmers have hitherto asked only about the weight of roots grown per acre," [2] without asking about the analysis of the roots. Two different strains of Eckendorf mangels were compared, of which one gave a considerably larger weight of roots per acre, while both gave the same amount of total solids or food-stuff per acre, because the roots of the second strain, although smaller, had a larger percentage of total solids. It was calculated that by growing the first strain a farmer with a 12 acre field would have to cart 50 cart loads of water home, which he could have drawn from his well much cheaper.

[1] Helweg's Report, 1901, pp. 185–87.
[2] Report by Helweg in "Om Landbrugets Kulturplanter," No. 9, København, 1891, p. 147.

Similar results could be shown for other varieties. "Farmers who insist upon buying other feeding-stuffs according to analysis must, therefore, necessarily soon demand from seed growers an analysis or guarantee of the food-producing character of the seed they buy."

In the annual reports on these competitions the characters, good or bad, of the roots grown were carefully pointed out, and a full description of his roots was sent to each grower, informing him of how he stood in comparison with other growers. The personal influence of Helweg with the growers was very great, and increased year by year. He was thereby enabled to induce many growers of seed from inferior stock to scrap their whole stock and start anew with seed from one of the best strains found among the competing samples. A grower, named B, was known to sell annually 10,000 lbs. of seed of a certain strain of mangel.[1] The Comparative Cultivations had shown that roots grown from his seed yielded so much less food-stuff per acre than roots grown from the seed of a grower E, that the annual loss to farmers buying the 100 cwts. of seed from B instead of buying from E amounted to £1500. Another grower of seed, also selling 100 cwts. of seed a year, caused a similar relative loss to his customers. And these two growers were found among only six sending in samples of the same variety. "Farmers would be fully justified, on the strength of these competitions, in entering a strong protest against buying root seed without a guarantee for the food-producing quality of the strain." Grower B scrapped his stock and started afresh with another stock as good as that of grower E.

By this influence of Helweg's, by the annual reports of the Society, by the explanatory reports sent privately to each competitor, and by articles in the agricultural papers, both growers of seed and farmers buying seed were gradually educated to understand the value of a good strain. Thus the aim already held out by Helweg as early as 1888, "gradually to weed out the poor and indifferent strains and to extend the use of seed of good strains," was steadily pursued, and the general stock of roots grown in the country was gradually improved to the benefit of farmers and of the country.

[1] Helweg's Report of 1901, p. 174.

In his report of 1901 Helweg formulated the chief result of the Competitive Cultivations from 1889 to 1899 as follows: "It is the strain more than the variety which determines the value of the root crop. The question which farmers had been asking for some years, viz.: Which variety shall I cultivate? was first gradually replaced by the question: Which strain shall I cultivate? And this question again led up to the inquiry: Where are the best strains to be obtained? This, then, is the question which the next series of competitions during the following ten years will have to solve."

The average yields in cwts. of solids or dry matter per acre of the three classes of strains of the various varieties were calculated for each of the six years, from 1894 to 1899, and from these again were found the average yields per class for all six years. These are given in the next table, together with the average number of strains tested annually.

Variety.	Average yield in cwts. of dry matter per acre.			Number of strains tested. Annual averages.		
	Class I.	Class II.	Class III.	Class I.	Class II.	Class III.
Barres	60·0	57·2	53·3	6	10	5
Elvetham	59·1	56·5	53·5	4	7	4
Eckendorf	55·2	53·8	49·6	4	6	4
Bangholm	60·9	—	52·5	1	1	3
Yellow Tankard	33·9	31·2	28·8	3	4	4
Funen Bortfeld	33·3	31·0	27·5	2	3	3
Champion	46·2	43·3	40·4	4	5	3
White Belgian	47·8	—	41·4	3	5	2

It will be noticed that of the fifty strains of mangels tested annually only a little more than a quarter came in Class I. and one quarter came in Class III. As the samples were derived from most of the best known seed growers in the country, it is likely that this proportion was no worse than the average for the country, in other words, that only a little more than one quarter of the acreage under mangels was sown with seeds of first-class strains, and that one quarter was sown with seeds of third-class strains. About the same applies to the cultivation

of carrots and turnips. The average yields in cwts. of solids or dry matter per acre for Class I. and Class III. were:—

For	Mangels.	Turnips.	Carrots.
Class I.	58·1	33·6	47·0
Class III.	52·1	28·2	40·9

The differences in value between the greater yields from strains of Class I. and the yields from strains of Class III. have been calculated per acre at the prices then ruling as:—

For	Mangels.	Turnips.	Carrots.
—	34*s.*	31*s.*	34*s.* 6*d.*

It would, therefore, evidently be a great gain to farmers if the third-class strains could be eliminated and the first-class strains could be more widely grown. That was the very result these competitions were aiming at, viz. to bring the first-class strains to the notice of farmers, and thus to induce them to neglect the inferior strains, and to show the seed growers, who worked with inferior strains, where they could get superior stock for their future seed growing.

With the year 1899 these preliminary investigations were brought to a close. The main result had been that the important aim must henceforth be to find the best strains in the country. This made it necessary in the Competitive Cultivations for the coming years to name the growers of the best strains. New rules for the next ten years' competitions were therefore published. Every autumn (first time in 1899) a notice was to be published by the State Committee on Plant Culture in the daily and agricultural press inviting growers of root seeds to enter, free of cost, samples for Competitive Cultivation on the Experimental Stations of the State. The samples were to be grown during one year only. They were to be of trade seed (not of stock seed), and to represent a quantity of at least 10 cwts. of seed of mangels or at least 5 cwts. of seed of turnips,

swedes, and carrots. The grower was to sign a declaration showing his production of seed during the previous three years, the origin of the strain, how long he had grown it, his method of improving the strain by selection or otherwise, with some other information. After cultivation the samples were to be divided into three classes in the way explained on page 38, and the names of growers of seed in Class I. were to be published in the annual reports in *Tidsskrift for Planteavl*,[1] the official journal of the State Committee. As it was impossible to find room at the Experimental Stations for samples of all the kinds of roots, these were divided into two groups, so that in 1900 and 1901 only samples of Barres, swedes, and carrots were grown; in 1902 and 1903 Elvetham, Eckendorf, and turnips; then in 1904 and 1905 again Barres, swedes, and carrots, and so on. As these plants are biennial, each seed grower usually worked with two strains. It was considered advisable to give the growers a chance of having both strains tested. That is the reason why the same kind of root was tested two years in succession, although each sample was to be grown only for one year. The samples were drawn in November-December by Helweg personally, 15 lbs. of mangel seed, 3½ lbs. of seed of the other kinds, and sent in bags sealed by him with the official lead seal of the Committee. Each sample was divided in two equal parts, of which one was kept for future reference, while the other was divided in three equal parts to be sent to the three stations where they were to be grown. After harvest the roots were examined, weighed, and analysed, the samples classified as explained, and a full report published in the following June, giving names of growers of samples of Class I. A reprint of the report was sent to each of the competing seed growers. Besides the names and addresses of the growers or "owners" of the strain, a full description of every strain in Class I. is given in each report, with detailed information of its origin, mode of selection, yield, and so on. The strains are generally called by the name of the grower's farm or by that of the village.

In 1900 27 strains of Barres were entered, 5 of swedes, and 4 of Champion carrots. For comparison's sake several samples of seed of the same varieties were bought from

[1] See that periodical, from 1902 to 1911.

well-known dealers in Denmark and abroad to be cultivated under the same conditions. Of the Barres strains 8 came in Class I. The yield of solids :—

were for	Class I.	68·6 to 66·5	cwts. per acre
„	Class II.	65·5 to 62·9	„ „ „
„	Class III. . . .	62·3 to 56·1	„ „ „

Four samples of Barres were bought abroad from the largest and most renowned firms, one from Scotland, one from France, and two from Germany. One yielded 64·7, the others between 61·4 and 58·5 cwts. per acre. One was therefore in Class II. and three in Class III. It will be seen that as early as 1900 the Danish seed was superior to seed of the same variety from the best firms abroad, of which seed large quantities were still in the Danish market. It will also be noted that the yield of the Danish samples varied considerably. Indeed, it was calculated, having reference to the quantity of seed represented by the samples, that if the seed of Class III. and of the lower half of Class II. were replaced by seed of Class I. it would represent a gain to farmers of nearly £10,000 annually.

It will not be necessary here to enter into greater details about these competitions from 1900 to 1910. It will be enough to state that the annual reports, giving names and addresses of growers from whom the best strains of seed could be bought, had a considerable effect. The price of seed of good strains increased to the benefit of the growers of these seeds, and the strains of inferior quality were neglected and gradually disappeared from the market. Imported seed could not maintain their position. It was pointed out in the eighth Report, 1909, that 30 samples of mangel seed and 17 samples of seed of swedes from the best firms abroad had been tested, and were found to be equal to Danish seed of Class III. only, yielding respectively 7·8 and 7·3 cwts. of solids per acre less than Danish seed of Class I. No wonder, therefore, that simultaneously with the inferior Danish strains the seed imported from France, Great Britain, and Germany also gradually lost ground, to be eventually totally replaced by Danish grown seed. The quality of root crops improved during these years, more acres were grown with roots, and the yield of food-stuff per acre increased to the distinct benefit of farmers. At the end of the ten years this preliminary

sorting of strains of roots had resulted in giving a few superior strains a dominating influence, just as intended.

But it was pointed out in the reports that the fact of a certain strain coming out on the top, or being classed as a first-class strain, by no means offered a guarantee that this strain would henceforth remain a first-class strain. On the one hand, there was always the possibility that other strains might be so improved as to surpass those previously considered the best; on the other hand, a strain might deteriorate if not continually cultivated in a way to maintain its high quality. The classification was, therefore, to be trusted only for a few years after the publication of the report. In order to be sure that a certain named strain was really of Class I., it would be necessary for buyers to know the date (year) of the classification.

The origin of many of the strains of mangels grown in Denmark has been traced back to a few samples of seed imported at an early date.[1] The well-known French horticulturist and writer, Pierre Philippe de Vilmorin, of the firm of Vilmorin-Andrieux and Co., of Paris (said to have been founded as long ago as 1727), cultivated on his estate "Des Barres," a mangel which he had improved by many years' selection. He called it "Jaune ovoïde des Barres" (oval yellow Barres), and first introduced the seed in the trade in 1853. The mangel was exhibited at the International Exhibition in Paris in 1855, and Prof. B. S. Jørgensen, from the Royal Agricultural College, Copenhagen, bought some seed, which he then sowed at the experimental fields of the College, where it was grown for seed for many years, improved by selection, and whence seed was supplied to Danish farmers and seed firms. In 1875 the Danish gardener, Fr. Wendt, bought 15 cwts. of seed of this Vilmorin Barres from Paris. During the following years several Danish firms dealt in seed of this French mangel, and from 1879 seed of it was grown in Denmark and offered for sale. For many years this variety of mangel was largely grown in Denmark, and about the year 1900 it was found to be superior to most of the competing strains.

[1] The following notes are taken from Helweg's exhaustive work, "De danske Barresstammer" (the "Danish Barres Strains, their Origin and the History of their Development"), in *Tidsskrift for Planteavl*, vol. 23, 1916, p. 289 ff.

No less importance attaches to a mangel of similar shape and colour but of a different origin. It is the Oval-shaped Yellow, or Yellow Intermediate, from Peter Lawson and Son, Edinburgh, a celebrated old firm founded in 1770.[1] Probably this is a very old English or Scotch variety, cultivated in Great Britain as early as 1812 as "Intermediate-shaped Yellow," or tankard-shaped, but giving many roots of oval shape. From these latter the Oval-shaped Yellow was probably produced by selection. It seems to have been fairly well known in Denmark in the seventies, and was shown at exhibitions in 1878 and 1880. About the year 1880 Chr. P. Jacobsen, of the firm Markfrøkontoret, now Trifolium, obtained samples of this and other varieties from Lawson and from other firms, as the firm intended to grow seeds of roots for sale. Of all the samples tried Jacobsen selected Lawson's Oval-shaped Yellow as the most suitable, and in 1885 he offered seed of his own growing from this English or Scottish mangel.

There were several other tankard- or oval-shaped yellow mangels at the Danish Exhibition in 1878, among them several German varieties. As they were all very much alike in appearance, and as Danish botanists thought it unnecessary and confusing to have different names for what was botanically the same variety, all these oval or half-long yellow mangels became gradually known under the common name of Barres. The Lawson Barres and the Vilmorin Barres, represented by the seed grown by Jacobsen and at the Royal Agricultural College respectively, were, however, recognised as distinct, and generally named after their introducers, Markfrøkontoret and the Royal Agricultural College. After protracted and severe competitions between these two kinds of Barres it seems that strains of the Lawson Barres are now ousting the Vilmorin and indeed all other mangels from the Danish fields.

One other kind of mangel of the more or less oval yellow variety, and therefore in Denmark called Barres, was undoubtedly derived from English stock, although it has not been possible to trace it back to the firm in Great Britain from which

[1] The firm is by some supposed to have been founded by a Dane of the name of Larsen, who "scotched" his name to Lawson (*Tidsskrift for Planteavl*, 19 vol., 1912, p. 78).

it was bought. It was cultivated in the eighties in several places in the district of Stevns, and is therefore known as Stevns Barres. It has some inclination to develop the tankard form, and may possibly be in some way related to the Eckendorf mangel. The definition of the mangels which in Denmark are known by the name of Barres is given by Helweg as follows: A longish or oval-shaped orange-coloured mangel, length generally a little more than double the width, the largest diameter being found a little above the middle. The flesh is white with a faint yellow tinge. The stalks of the leaves are green, not yellow.

How the many Danish strains, descended from these original samples, have behaved at the Comparative Cultivations is fully illustrated by a report of Helweg's in 1916,[1] which can be usefully mentioned here, although it means anticipating some results of the following years' competition to be dealt with later on. He gives first a review of the total number of samples entered for competition under the name of Barres during the different years, classifying them according to their origin :—

Years of cultivation.	Vilmorin Barres.	Lawson Barres.	Stevns Barres.	Unknown origin.	Not Barres.
1900 and 1901 . . .	25	3	0	34	4
1904 and 1905 . . .	17	10	2	29	3
1908 and 1909 . . .	5	17	2	17	2
1911, 1912 and 1913 . .	2	12	2	3	1

It appears from the last column that some seed growers entered samples as Barres which when grown were found not to possess all the characteristics of a Barres. The last but one column contains samples of unknown origin; they may be of British, French, or German origin, or crosses. It will be seen that they gradually dwindle in number. The greatest interest attaches to the samples of known origin, of which the first column represents samples of Danish grown seed descended from the Vilmorin Barres. The stock seed on which the growers worked had in most cases been directly or indirectly derived from the seed grown at the Royal Agricultural College and

[1] *Tidsskrift for Planteavl*, 23 vol., 1916, p. 313.

originally imported in 1855. It will be noticed that these strains also gradually fall off. The second column represents samples of seed descended from Lawson's Oval-shaped Yellow or Yellow Intermediate, and mostly produced from stock seed supplied by Markfrøkontoret (Trifolium). This excellent Barres has alone increased in importance, as shown by the increasing number of strains entered for competition.

The reason for the change in the number of strains of different origin entered is simple enough. The results of the competitions showed growers of some strains that the yield of their strains was unsatisfactory ; they therefore changed their stock seed, and have generally taken new stock from one of the descendants of the Lawson Barres as being the best yielding strains.

Another table of Helweg's shows the number of strains of the different groups which were placed in Class I. The " not Barres " are omitted, as also are the Stevns Barres, of which only one, known as " Lille Taarøje," came in Class I., where it has maintained its position. Dealing then with the other three groups, the following strains were placed in Class I. :—

	Vilmorin Barres.	Lawson Barres.	Barres of unknown origin.
Years 1900–01 . . .	6 strains	Sludstrup	5 strains
Years 1904–05 . . .	2 other strains	Sludstrup Ferritslev Rosted Slagslunde	5 other strains
Years 1908–09 . . .	None	Sludstrup Ferritslev Rosted	3 strains, being one from each of the previous periods, and one other strain.
Years 1911, 12, and 13 .	None.	Sludstrup IV. Ferritslev IV. Rosted IV.	None.

This is a very important table, which fully illustrates what

was said on an earlier page that the fact of a strain being placed in Class I. does not necessarily prove that it will remain a Class I. strain. The Vilmorin strains which were in Class I. in 1900–01 were all declassed during the next competition. Two "other" Vilmorin strains came in Class I. in the next competition, 1904–05, but were again declassed in 1908–09, and none of the Vilmorin strains have been found worthy of a Class I. certificate in the competitions held in 1908–09 and from 1911 to 1913. Similarly with those of unknown origin. The five Class I. strains in 1900–01 were all declassed in the next period. Five "other" strains were placed in Class I. in 1904–05, but all but one were declassed in the next period. In this period, 1908–09, one from the previous period and one from 1900–01, together with one new strain, appeared in Class I., but all three were declassed in the next period. It does not necessarily follow that these declassed strains had deteriorated; they may have gone down in class chiefly because competition became keener as the strains of the Lawson Barres group were improved and moved up. And a remarkable characteristic of these Lawson Barres strains is this, that when once they reach Class I. they maintain their position, always supposing, of course, that they are grown under proper conditions with continued selection. We will, therefore, deal more fully with these strains.

The Ferritslev strain is descended from seed which Hans Tygesen, owner of a peasant farm in Ferritslev, Funen, bought in 1883 from Chr. P. Jacobsen. As Jacobsen (Markfrøkontoret) at that time did not grow the Lawson Barres for seed, Tygesen must have bought seed which Jacobsen had received from Lawson. The strain was first entered for competition in 1904, the owners being The Ferritslev Seed Growers' Association.

The Rosted Strain is derived from stock seed grown by Markfrøkontoret from Lawson's seed. In 1885 a village schoolmaster [1] named Fraas "bought of this stock seed at 3*s.* per lb." He grew stock seed for Markfrøkontoret, and from this seed another village schoolmaster, Michelsen, in Sludstrup, Sealand, bought seed in 1887, and from him some stock seed

[1] By Royal Decree of 1814 village schoolmasters were, as part of their salary, to have a small-holding sufficient to feed two cows and six sheep. Many schoolmasters have cultivated their holdings very well and set an example to the peasants in their village.

was sold in 1893 to J. Jørgensen, a seed grower in Rosted, Sealand, whose farm gave the name to the strain.

These two strains, both descended from Lawson's Oval-shaped Yellow, have developed sufficiently distinct characters to deserve to be named as different strains.

The Sludstrup strain is a cross produced by Michelsen, Sludstrup, in 1896, by crossing the Lawson strain, which he obtained in 1887 from Markfrøkontoret, with the Vilmorin strain, of which in 1895 and 1896 he obtained seed direct from the Royal Agricultural College. The Sludstrup strain has acquired characters from both the parent strains, and is an intermediate form between those two.

Helweg has estimated the relative quantities of the various varieties of mangel seed sold in Denmark in 1884 and in 1915 to be:—

	In 1884. per cent.	In 1915. per cent.
Of Barres	21	88·5
„ Eckendorf	6	9
„ Elvetham	61	2
„ other varieties	12	0·5

Among the other kinds of roots a special variety of yellow-fleshed turnip deserves to be mentioned, viz. Bortfeld. This was originally a German root intended for the kitchen. In 1885 Chr. Dæhnfeld, of the firm of L. Dæhnfeld, Odense, noticed some fine large specimens in the local market and secured seed from the grower. He found that they developed so rapidly that they could be sown in the autumn after rye on land which was otherwise left fallow. In 1888 the seed was offered to the trade and shown at exhibitions at Copenhagen under the name Funen Bortfeld. This kind of turnip is now grown extensively both in Denmark and Sweden, and competes with Yellow Tankard. It is a long oval root, cream coloured, the top being of the same colour as the lower part.

The second series of the Comparative Cultivations of the different strains of roots held from 1900 to 1910 had effected a rough sorting, many less productive strains had dropped out, and the good strains had become more widely grown. A great step forward had been made, such as had been contemplated by Helweg in 1888, viz. a few good strains held the field. This is an advantage, inasmuch as the work of improving the strains

can be concentrated on these few. The farmers, too, benefitted now that information as to where to buy the best seed was available. They were spared the trouble and uncertainty of having to decide which of the many well-advertised varieties with enticing new names they should choose, and they reaped the advantage of better yielding crops.

It was evident that the competitions during the next years would be between a few selected strains and sub-strains derived from these. A far closer contest between the competing strains could be foreseen, and therefore a sharper, more searching test was required. At a meeting of the State Committee in March, 1910, new rules for future competitions were consequently proposed by Helweg and carried.[1] The object was declared to be as hitherto to obtain a greater yield from the root fields of the country; the means was to assist seed growers to improve their strains by offering them reliable information as to how their strains compared with others. In order to obtain greater reliability, it was decided to grow the samples during three consecutive years, each sample of seed entered being divided into three portions, one to be sown each year. Invitations were to be published by the State Committee every third year in September to seed growers with a stock of at least 10 cwts. of seed of mangels, or at least 5 cwts. of seed of turnips or swedes, or $2\frac{1}{2}$ cwts. of seed of carrots, to enter samples of their strains, to have them tested by comparison with other samples by growing them three years in succession. It was a condition, however, that the seed grower should have cultivated the strain for at least six years. New varieties or strains from other countries could be accepted. Each sample of seed was to be grown on at least four of the official Experimental Stations. The samples of seed, to be delivered free of cost, were to be drawn by Helweg during the month of December as an average sample of the whole stock of trade seed. The samples were dried to enable them to keep, and the germination was tested each year.

It was a drawback to this arrangement that growers had to wait so long for the result. It was therefore decided that a

[1] *Beretning fra Statens Planteavlsudvalg*, København, 1911, p. 77 and 135.

preliminary calculation of the result should be made after two years' working, and that from those seed growers, whose strains had given the highest yields during these two years, additional samples were to be drawn from their stock seed to be compared with the previously drawn samples of their trade seed. After the three years' cultivation the results were to be calculated for the trade seed and published during the following month of March in *Tidsskrift for Planteavl.* The samples were placed in order according to their yields, these being calculated as averages for all three years and at all stations, and the names were to be mentioned of all growers whose strains had been placed in the first half at any one station, according to the averages for the three years at that station.

To every seed grower whose strain had been examined a copy was sent of the final report, together with a certificate signed by Helweg and all the directors of the Experimental Stations, showing how his strain was placed according to yield and with a full description of the characters of the strain as revealed by the examination. In this way a grower was enabled to prove when his strain had obtained a Class I. certificate at the State Competitions. Copies of all certificates and of the declarations signed by the growers stating the origin and history of their strains were deposited with the State Committee.

In addition to the main report dealing with the trade seed a report was drawn up showing how the samples of stock seed compared with the trade seed. The results of these reports were looked forward to with the keenest interest. When the samples of stock seed were drawn all the bags were officially sealed by Helweg. As soon as the results were published showing which strains had yielded the most, *i.e.* the greatest quantity of food-stuff per acre, there was a rush from seed merchants to buy of the stock seed. Owners of these strains received telegraphic orders at unlimited price. The Root Seed Commissioner would then visit the seed growers, open the sealed bags and see the stock seed weighed out by the owner to his different customers. He then sealed the bags so that the stock seed of the strains of Class I. was delivered to the buyers under official seal and with a guarantee that it was of the strain stated. For this stock seed a price up to £2 per lb. was

commonly paid for mangel seed, and £3 for seed of swedes or turnips, and many a small seed grower has reaped a rich reward for his labour in improving his strain.

Before giving the results of the three-year competitions in this third series it will be necessary to explain an innovation in the way of describing the first-class strains. In 1900 a strain of Barres mangel, Sludstrup, was placed in Class I. For the competition of 1911–13 eight strains, derived from this Sludstrup strain, were entered, of which only two were found to be of Class I., four were of Class II., and two even as low as Class III. This confirms what has been mentioned previously that a statement or a certificate showing a strain to be of Class I. is valid only for a limited number of years, as by careless seed growing from ordinary trade seed a strain can degenerate in the course of a few years. It would be manifestly unjust to the owner of a Sludstrup strain of Class I. that a degenerated third-class strain should bear the same name, even if derived from a stock of the original first-class Sludstrup. And it would be misleading to farmers and would entirely neutralise the effect of these competitions if those strains, which were really Class I. could not be distinguished from degenerate derivates of former first-class strains. The object of distinguishing those strains, which at a given time are first-class strains, has been attained in a manner equally simple and effective. The competition of 1911–13 was the fourth one in connection with which the names of the best strains of mangels were published. The strains found to be of Class I. at the competition of 1911–13 are therefore named Sludstrup IV., Rosted IV., and so on, with the Roman figure IV. added to the name, showing at what date, in which competition, the strain obtained its Class I. certificate. Similarly the first-class strains at the competition of 1914–16 are distinguished by the Roman figure V., and so on. A name such as "Ferritslev V." is a trade description which can be protected in the Courts, and the sale of seed of Ferritslev IV. as if it were seed of Ferritslev V. is an infringement of the law.

For the competition held in 1911–13 there were entered 20 strains of *Barres*, and of *Turnips:* 3 strains of Yellow Tankard, 9 of Funen Bortfeld, and 4 of round turnips, besides 6 strains

of *Carrots*.[1] Of *Barres* six strains were placed in Class I., viz. two Sludstrup, three Rosted, and one Ferritslev. The origin of these strains has been explained, see pp. 54 and 55.

Ferritslev IV. is the same as that described on p. 54, kept up by continued selection. It has a large percentage of dry matter. The roots are oblong cylindrical with a blunt lower end. The top is small.

Rosted IV. One of the sub-strains has been cultivated by Jørgensen by ordinary selection. Another is derived from seed which D. L. F. (*i.e.* the Danish Agricultural Societies' Seed Supply, Roskilde) bought in 1906 from Jørgensen and has cultivated by selection. The third sub-strain belongs to the firm of Trifolium, which in 1906 bought seed from Jørgensen and improved the strain by selecting the 13 best of 99 families. It has a larger percentage of dry matter but a somewhat smaller yield of roots than Ferritslev IV., which it resembles in shape.

Sludstrup IV. In 1901 F. D. B. (*i.e.* the Co-operative Wholesale Society of Denmark) bought seed from Michelsen and cultivated it. The strain was entered and obtained Class I. certificate in 1908. In 1908 56 families of the strain were cultivated on the Society's farm at Lyngby and the 16 best families selected. From selected roots of these 16 families the seed had been derived, which was entered in 1910.

Another sub-strain was derived from seed bought in 1902 from Michelsen.

Percentage of dry matter somewhat higher and the yield of roots correspondingly lower than those of Rosted IV. The roots are well-shaped, smooth, long oval, slightly tapering at the lower end. Top rather heavy.

Of the *Turnip Yellow Tankard* two were in Class I.

Pajbjerg IV. Chr. P. Jacobsen (Markfrøkontoret) bought seed of Yellow Tankard from P. Lawson and Co., and in 1886 began to grow stock seed. In 1895 J. Hvidberg, of Pajbjerg, bought some stock seed from Markfrøkontoret and some trade seed from Lawson and selected those roots for seed which had

[1] L. Helweg, 76 Report, *Tidsskrift for Planteavl*, 21 vol., København, 1914, p. 33.

the highest specific gravity.[1] Since 1902 selection by families has been used to improve the strain.

Amagergaard IV. (Trifolium) is derived from the Pajbjerg strain, but has been considerably changed by several years' selection by families. This strain has a somewhat higher percentage of dry matter with a comparatively lower yield of roots than Pajbjerg IV.

Of *Funen Bortfeld* two were in Class I.

Hundslev IV., which strain was in Class I. as early as the competition in 1902 and again in 1906–7. The owner is Jakob Hansen, Hundslev, Ladby.

Amagergaard IV., derived from seed of Hundslev which Trifolium bought in 1907.

Of *Carrots* two were in Class I.

Hinnerupgaard IV., a James' carrot imported from England fourteen years previously, and cultivated by selection by the firm of L. Dæhnfeldt, Odense. This strain has a very large percentage of dry matter. The roots are unusually smooth, of a fine dark-red colour, long conical with a sharp point.

Helgeness IV., a strain which has been cultivated since 1900 by the firm of Fr. Dreyer, Aarhus. Was also in Class I. in 1909. It is a very large cropper but with a low percentage of dry matter, almost cylindrical, only slightly tapering towards the blunt end. Top small.

For the competition held in 1914–16 [2] 22 strains of Barres and 15 strains of Swedes were entered, and 4 samples of Swedes were bought from abroad for comparison. Six *Barres* strains came in Class I., one of them being the immediate successor of a strain placed at the previous competition, viz. :

Ferritslev V. Of the others one was—

Lille Taarøje V., which is a Stevns Barres. It was in Class I. in 1904. The original owner, Ole Olsen, Lille Taarøje, has cultivated stock seed of this strain since 1888. The firm of R. Wiboltt, Nakskov, in 1905 bought seed of 100 roots. Of the resulting families only 5 were kept, and the following year all discarded but one from which the strain is descended. It has

[1] L. Helweg, *Tidsskrift for Landbrugets Planteavl*, København, 1904, p. 10.

[2] L. Helweg, 113 Report, *Tidsskrift for Planteavl*, 24 vol., København, 1917, p. 1.

a large yield of roots but a low percentage of dry matter. The roots are ovoid in shape with a blunt lower end. The top is small with fine leaves.

Strynø V. is derived from seed bought in 1898 from Markfrøkontoret, to which firm the seed had come from P. Lawson. The strain has been cultivated by Rasmus Kold, Strynø, Rudkøbing, since 1898 and carefully selected. It has a higher percentage of dry matter than Lille Taarøje and a very much larger yield of roots. The roots are somewhat longer and the top rather larger.

Sludstrup V. A sub-strain of Michelsen's Sludstrup came in Class I. in 1908. The firm of L. Dæhnfeldt, Odense, bought seed of it in 1909, and this was cultivated by families, and selected first 14 out of 120, then 4 out of the 14. Each of the four gave again 10 families, of which 3 or 4 were kept. In shape and character like Sludstrup IV.

Tystofte V. A strain probably derived from the Vilmorin Barres and cultivated from the early nineties by P. Nielsen, and after him improved by family selection. It is like Sludstrup as regards dry matter but yielding rather more. Also like it in shape and top.

Pajbjerg V. J. Hvidberg in 1909 bought seed of the same sub-strain as mentioned under Sludstrup V. Of 100 families one, No. 55, was selected in 1910 and eight roots of it planted for seed. From these the strain has been developed and differs so greatly from the original Sludstrup that it has deserved a new name. It has a larger percentage of dry matter than any of the other strains but a correspondingly lower yield of roots. The shape is oblong with a blunt lower end, the top is large.

Of the *Swedes* six came in Class I., three Olsgaard, two Pajbjerg, and one Lyngby.

Olsgaard V. The seed of this Swede was probably in 1886 supplied by the firm of Hurst and Son, London. The strain was in Class I. in 1904, 1908 and 1909. From 1902 to 1910 family selection was used.

Another strain is derived from seed which R. Wiboltt bought in 1905 and 1906 and improved by family selection.

Pajbjerg V. This strain, belonging to J. Hvidberg, was in

Class I. in 1901, 1905, 1908, and 1909, or in all the competitions of swedes held so far. It has been improved by family selection.

The other strain is derived from seed bought in 1909.

Lyngby V. belongs to F. D. B. and was in Class I. in 1909. This strain is descended from the Olsgaard strain. Jørgensen, the manager of the F. D. B.'s seed farm at Lyngby, selected some Olsgaard swedes in 1902 and has improved the strain by family selection.

These swedes are all of the Bangholm kind, in shape globular, slightly oblong. The Olsgaard and Lyngby strains have a large yield with a somewhat lower percentage of dry matter, while the Pajbjerg have a large percentage of dry matter and a somewhat smaller yield of roots.

The result of the competition of 1917–19 will be published in March, 1920. For this competition 20 strains of Eckendorf mangels, 31 strains of Turnips, and 13 of Carrots were entered.

The strains with Roman figure IV. and figure V. are not only sold by owners to farmers, but all the large and good seed firms will buy stock seed or get such in exchange for their own strains. But seed of strains IV., bought as stock seed in 1914, could not be ready for the trade before 1916, and similarly seed of strains V., bought as stock seed in 1917, have only been offered for sowing in the spring of 1919.

The Committee feel that by the 2nd series (1900–1910) and the 3rd series (1911–19) enough has been accomplished by way of educating farmers to appreciate the necessity of buying seed only of the best strains, and in pointing out to them where such seed can be obtained. A new series will, therefore, begin with the year 1920. The object of this series is to serve more particularly the interests of the seed merchants. Up to the present samples of trade seed have been compared, with the tentative inclusion, in the case of the 3rd series, of stock seed during the last year of the competition. The new series will deal principally with stock seed, the idea being to find out where seed merchants can buy the best stock seed for cultivation through their seed growers or on their own farms. As previously pointed out, the guarantee that a certain strain is of Class I. is valid only for a limited number of years. The new series will make it possible to have the verdict ready two years closer to the time when the

stock seed is available than it was in the case of the previous series. This will not only benefit the farmers, but will enable seed growers to get a judgment on the result of their work in improving their strain two years sooner than when, as in earlier series, the trade seed was examined.

The working scheme has been fixed as follows: The competition is to be for four years. Samples of stock seed are called up to be cultivated for two years on the seven stations and three branch stations, each sample to be cultivated on at least five stations in the way described above. At the end of the second year the results are calculated and the samples classified according to yield. The samples that come in the lower half are then discarded, and only the samples in the upper half are to be further examined. For each sample in the upper half two new samples are called for from the owners of the strain, viz. one sample of trade seed cultivated from the stock seed already examined and one sample of the new generation of stock seed. These samples are then to be cultivated for two years in succession, when the result of the four years' cultivation will be published.

The strains placed in Class I. by the first four years' competition will have the Roman figure VI., and stock seed of these strains will be available in the spring of 1924, and trade seed with figure VI. will be on the market in 1926. By that time strains IV. should be considered superannuated and no longer reliable.

As has been mentioned, seed from the best firms in other countries have been bought and cultivated in competition with home-grown strains at several of the competitions. They have been obtained from firms in France, England, Scotland, Germany, and a few from other countries, and it is intended for the future to continue this cultivation of the best strains to be obtained from other countries. If better strains could be obtained from abroad, *i.e.* strains which would yield a greater quantity of total solids per acre when grown in Denmark than what was yielded by the home-grown strains, such foreign strains would then be adopted for cultivation in Denmark. Only once, since 1889, viz. in 1900, was a Swede, a Bangholm from Edinburgh, found to be superior to Danish strains, but

although several samples were bought in the following years from the same firm, none of these came up to the standard of the first-class strains of Danish Swedes.

Between 1900 and 1908 thirty samples of Mangels were bought from Great Britain, France, and Germany,[1] and their yields of solids in cwts. per acre were found by cultivating in the usual manner. For the sake of comparison the average yield of solids, in cwts. per acre, of the first class of Danish strains for the year in question is taken as unit and called 100. The average yield of the 30 foreign samples of mangels for these years was found to be only 89·2, or nearly 11 per cent. below the yield of the Danish strains. The samples from Great Britain averaged only 86·1, or nearly 14 per cent. less than Danish first-class strains, the lowest giving 80·4 and the highest (2 samples) 91·5 per cent. of the yield of Danish first-class strains. The foreign samples yielded about the same as Danish strains of Class III.

Similarly for Swedes. Nineteen foreign samples were tried during the years 1900–1909, all but three being from Great Britain. The average yield of these was 89·5, or 10·5 per cent. below the average for first-class Danish strains of Swedes, the lowest being 81·7, the highest the Scottish Bangholm, in 1900, 102·8. On the average the foreign Swedes yielded, when grown in Denmark, only as much as Danish strains of Class III. In 1914–16 [2] four more British samples of Swedes were tested, yielding from 87 to 89 per cent. of the yield of the Danish strains of Roman figure V.

With some justification Helweg advised Danish farmers not to buy seed of foreign roots before these had been tested in the Danish Competitions.

[1] L. Helweg, 41 Report, *Tidsskrift for Landbrugets Planteavl*, 16 vol., København, 1909, p. 273.

[2] L. Helweg, 113 Report, *Tidsskrift for Planteavl*, 24 vol., København, 1917, p. 39.

CHAPTER III

IMPROVED STRAINS OF GRASSES, SELECTED BY COMPARATIVE CULTIVATION AT THE EXPERIMENTAL STATIONS OF THE STATE

The cultivation of roots was neglected in Denmark as late as the middle of last century. Fields were left fallow instead of being used for root crops, and the root crops grown were very indifferent, a result partly due to bad seed and partly to indifferent methods of cultivation. The cultivation of grass fields was similarly neglected. Grass in rotation played then, as it still does, a very important part in the economy of the farm, inasmuch as about one-third of the arable land is sown with grass in rotation. But the crops raised were very poor. Fields were left in grass for three or four years, and little attention was paid to the quality of seed sown or to mixtures of seed of various kinds best suited to produce a good crop for one or more years. In 1875 E. Møller Holst caused a large number of samples of grass seed, as used by Danish farmers, to be collected from all over the country, which he analysed and found to be of very poor quality. On one-third of their arable land Danish farmers produced but scanty crops. As they had nothing else to offer their cattle in the spring, these were turned out early on to the poor grass fields, and but little hay was saved for the winter fodder.

The work of one man wrought a great change and improvement in this branch of agriculture. P. Nielsen was born in 1829, the son of an agricultural labourer in Slesvig. Ten years old he had to go into service, but his thirst for knowledge was so strong that he, when twenty-six years old, borrowed the necessary means to enable him to attend a school. Two years later he became a teacher under an admirable principal, and later on was appointed schoolmaster at Ørslev, near Skjelskør,

in which position he remained for twenty-seven years. He published several botanical treatises. In 1869 appeared his first publication on the improvement of grass fields, and in 1878 he read a paper before the Royal Agricultural Society of Denmark,[1] in which the results of his investigations appeared in a clear and reasoned form, which established his position as an authority on the question of rotation grasses. He showed how red clover (*trifolium pratense*) generally fails during the second year's grass; and as this was at the time the only leguminous plant sown in rotation grass, the fields were often without this important ingredient after the first year. It was therefore necessary to use other leguminosæ besides red clover. Ryegrass (*lolium perenne*) and particularly Italian ryegrass (*lolium italicum*) he found unreliable, and timothy to appear too late. In order to ensure a better crop the second and third year, he therefore recommended such grasses which, even if appearing sparsely the first year, grow more freely when the first year's plants leave them room to develop. As such grasses he recommended cocksfoot (*dactylis glomerata*), tall oat grass (*avena elatior*), and meadow fescue (*festuca pratensis*). For a number of years he put his theories into practice on the extensive grass fields on farms belonging to E. Tesdorpf, a president of the Royal Agricultural Society of Denmark. It lies beyond the scope of this book to describe P. Nielsen's important work, which has had a great influence on agriculture in his own country, and has been duly appreciated among agricultural experts in other countries. Numerous reports of his are found in *Tidsskrift for Landøkonomi*, and other periodicals. A *resumé* of his analytical investigations of the plants of grass fields during the years 1877 to 1888 was written in 1908 by E. Lindhard, formerly his assistant, now his successor as director of the State Experimental Station at Tystofte.[2] The State bought a farm at Tystofte, and in 1886 appointed P. Nielsen as its manager, in order to enable him to continue his investigations, which hitherto he had carried out on the small-holding

[1] *Tidsskrift for Landøkonomi*, 12 vol., København, 1878, p. 620.

[2] E. Lindhard, "En Analytisk Undersøgelse af Plantedækket i en-og fleraarige Græsmarker," 1877–1888, *Tidsskrift for Landbrugets Planteavl*, 15 vol., København, 1908, pp. 185 to 312.

which belonged to him as the village schoolmaster of Ørslev. This was the first Experimental Station of the State. On his small-holding at Ørslev P. Nielsen had evolved a system of field culture distinct from the Rothamsted system, which had been adopted at the Royal Agricultural College, Copenhagen. While at Rothamsted field experiments were carried out on whole fields or on plots sufficiently large to secure a uniform result, P. Nielsen introduced the system of small "parallel plots" systematically distributed on the field, all of the same size, not separated by path-ways, but surrounded by screening belts of the same crops. By securing the greatest possible uniformity of soil, method of cultivation, manuring, and so on, and by repeating his experiments during a series of years, he obtained reliable results. His system has since been followed on the official Experimental Stations of the Danish State, and has been adopted in many other countries. How the Comparative Cultivations of roots are carried out according to his system has been described in a preceding chapter (pp. 36 to 40). P. Nielsen died in 1897.

His investigations on the rotation grass fields caused a demand for seed of several kinds of grasses and luguminosæ not hitherto used to any extent. He initiated a long series of experimental cultivations of these plants from seed from various places abroad in order to test their relative yield; and numerous reports from the directors of the Experimental Stations appeared in the official journal, *Tidsskrift for Planteavl.* By these reports and by short communications to the weekly agricultural papers, often with illustrations, farmers and seed merchants were taught where the seed could be bought which would yield the greatest crop when grown in Denmark. Sometimes seed of red clover was bought from Italy or France, where it was cheap, although seed from those countries often yielded very unsatisfactory crops, the plants being unable to withstand the Danish winter. P. Nielsen proved that seed of red clover from Russia, Silesia, or Bohemia would yield several times more than seed from Italy. Similarly with the other kinds of seed used in the grass fields.

One result of P. Nielsen's work soon appeared in the statistics of the trade in seed, which showed that the amount of seed

used for the constant area of rotation grasses increased rapidly and changed its character. While Denmark's net import of seed of all kinds was in 1875 3500 tons, it was in 1895 7300 tons, and in 1906 9050, the greater part being seed of clover and grasses. It is estimated that in 1908 4450 tons of grass seed were used, of which only 950 tons were home grown ; and that 3000 tons of seed of clover and other leguminosæ were used, nearly all being imported.[1] While in 1875 the import of grass seed only comprised timothy (*phleum pratense*) and English and Italian ryegrass, with red, white, and alsike clover (*trifolium pratense, repens* and *hybridum*), the import in 1895 included cocksfoot, meadow fescue, tall oat grass, brome grasses (*bromus arvensis* amd *mollis*), yellow trefoil (*medicago lupulina*), and kidney vetch (*anthyllis vulneraria*).

The home grown grass seed was mostly such as the farmers saved on their fields. About the year 1900 a more systematic cultivation of grass seed began, but for a long time made little headway. Gustav Hage [2] mentions that Chr. P. Jacobsen had begun a small export of home grown cocksfoot and meadow fescue as early as in 1878, and that it was continued by the firm of Trifolium, of which Hage was a director. The total area devoted to seed culture was in 1901 only 10,600 acres, in 1907 even somewhat less, but from that year the area increased, and was in 1912 39,000, and in 1919 close upon 78,000 acres.[3]

At the time when, thanks to the systematic work of Helweg and others, production of and trade in root seed was already in a good way of being organised, the production of Danish grass seed still lacked all system and control. Some farmers grew grass seed, but not very pure, and if prices did not suit them they cut the grass and used it for hay. About the year 1906 a systematic cultivation of seed of cocksfoot was begun by several firms, such as L. Dæhnfeldt and others, who had their grass seed grown by farmers under contract in the same way as practised with root seed, the firms supplying the growers with seed, preferably stock seed, all the harvested seed to be

[1] Gustav Hage, "Om Frøhandel," *Tidsskrift for Landbrugets Planteavl*, 19 vol., København, 1912, p. 77.
[2] l. c., p. 88.
[3] *Statistiske Efterretninger*, 11 vol., København, 1919, p. 86.

delivered to the firms for sale. Gradually the growing of seed of other kinds of grasses was introduced. The value of the seed delivered is calculated according to its purity, germination, and other characters, as determined by the Seed Testing Station of the State. An association of farmers, "The Associated Danish Agricultural Societies' Seed Supply" (Danske Landboforeningers Frøforsyning, or D. L. F.), Roskilde, was also started in 1906, for the purpose of increasing the home production of seed corn and seed, in order to supply members with seed of uniform quality and with a reliable guarantee, and also for the export of Danish grown seed of good quality. All the societies of small-holders, and 105 of the 120 agricultural societies in Denmark, are now affiliated to the D. L. F. The D. L. F. from the first co-operated with the Co-operative Wholesale Society of Denmark (known as F. D. B.). The F. D. B. had for some years supplied members of the co-operative distributive societies all over the country, who were mostly farmers, with seed, and had since 1904 had their own farm at Lyngby, where they grew and improved stock seed. They also had their own stock seed grown by seed growers for the production of seed for trade, in the same way as most of the large seed merchants. In 1912 the D. L. F. took over from the F. D. B. the growing of seed, the latter society distributing the seed through the local distributive co-operative societies. The F. D. B., however, continued its cultivation and improvement of stock seed. The D. L. F. have several farms for growing stock seed, control samples of consignments sold, and so on, in the same way as the large seed merchants. Through this development of the production of and the trade in grass seed by the seed merchants and the co-operative societies the import gradually decreased and an export began, which has now attained considerable dimensions.

The quantities of seed for rotation grasses used in Denmark were in 1912 estimated at 4650 tons of grass seed and 3350 tons of seed of clover and other leguminosæ. But while of the latter only about 2 per cent. were home grown, the production of grass seed was about 6000 tons, or more than required for home use. Of this quantity 3000 tons were of cocksfoot, of which kind only about 800 tons were required for home use. The remainder

was therefore exported, chiefly to England and the United States, while a quantity of ryegrass, timothy, tall oat grass, and some other kinds were imported.[1] In 1905 Denmark had, according to Hage, a net import of cocksfoot of 650 tons from New Zealand and U.S.A. By 1908 the import had been reduced to 475 tons because of the increased home production. Dorph Petersen estimates the export of home grown cocksfoot in 1913 at 2000 tons, and a similar or somewhat larger export has taken place during the year next following. The production of meadow fescue, brome grass, English and Italian ryegrass, and of rough-stalked meadow grass (*poa trivialis*), has also been so much extended that the home market has been fully supplied, and there has been an increasing export of Italian ryegrass, meadow fescue, and rough-stalked meadow grass. Denmark is practically the only country which has an export of the last-mentioned kind of grass seed; but the world's requirement of import is very small, and the production on 300 acres is enough to satisfy this demand.

This large and rapid increase in the cultivation of grass seed and export of several kinds of grass seed from Denmark is a natural development. The climate and the agricultural conditions in general are singularly favourable to this production. The increase in quantity has been closely accompanied by an improvement in the quality. The contents of seed of other cultivated plants in the samples of Danish grass seed has been gradually reduced, and is now only from ½ to 1 per cent., while the germination per cent. is generally from 95 to 98. Cocksfoot was formerly sold according to bushel weight, 16 to 17 lbs. per bushel. Danish exporters introduced selling according to purity and germination. It used to be quite common in the world's trade to be satisfied with a purity of 80 to 85 per cent. The trade in Danish cockfoot seed, with a purity of 90 to 95 per cent., has had the effect of stiffening the requirement, and a purity of 95 per cent. is now sometimes insisted on by British buyers. The general trade requirement is, however, 90 per cent. of purity and 90 per cent. of germination.

[1] K. Dorph-Petersen, "Græs-og Kløverfrøavlen i Danmark," 1907–13, *Tidsskrift for Planteavl*, 21 vol., København, 1914, p. 662. And same, "Handelen med Græsfrø," *ibid.*, 23 vol., 1916, p. 650.

Until lately most of the English ryegrass and an appreciable proportion of the Italian ryegrass used in Denmark was imported from Ireland, and the Irish ryegrass seed was very cheap. But it was inferior to the home grown English ryegrass. This had a germination of 96 to 98 per cent., while that of the Irish seed was 10 to 20 per cent. lower. The Danish strains were also much more resistent to the attack of rust, and yielded about 18 cwts. more hay per acre. When Danish farmers grasped this difference in the quality of the seed from Ireland and Denmark, which was pointed out to them in a series of articles by Dorph-Petersen,[1] and later on in the price list of the D. L. F., they showed their appreciation by paying a much higher price for the home grown seed. In 1916 D. L. F. charged the following prices in the retail trade to farmers :—

For English ryegrass,	from Ireland	30*s.* per cwt.
„ „ „	Lundbek strain	44*s.* „ „
For Italian ryegrass,	from Ireland	33*s.* „ „
„ „ „	D. L. F. strain	47*s.* „ „
„ „ „	Tystofte 152	55*s.* „ „

and notwithstanding these differences in prices, D. L. F. had sold three times as much of home grown English ryegrass seed and six times as much of home grown Italian ryegrass seed as of the Irish seed by the time all the Danish seed had been sold.

Different strains of grasses were grown for seed in Denmark. From 1879 to 1907 the yield of hay grown from seed of various strains of clover and grasses from different places of origin had been compared by cultivation at the Experimental Stations of the State, the comparison being between samples of both imported and home grown seed.[2] It had been found that there were in the country several strains yielding better crops than the imported seed, and also that there were considerable differences between the different strains in cultivation. The State Committee on Plant Culture decided in 1908 to arrange for Comparative Cultivations of samples of seed of clover and grasses in a similar manner to that employed for many years with roots, in order to find the best strains in the country, to encourage the production of seed from these, and to weed out

[1] Vort Landbrug, 1905.

[2] 48th Report, *Tidsskrift for Landbrugets Planteavl*, 17 vol., København, 1910, p. 181.

the inferior strains. Two different objects might be aimed at, either to find those strains which produced the largest amount of seed, or to find those which produced the greatest quantity of hay. The first might seem at the first glance to offer the greatest advantage to seed growers and seed merchants, while evidently the production of hay was what the farmers were interested in. As, however, the seed grower will find it his best policy in the long run to study the interest of his customers, it was decided that the aim of these competitions should be to find those strains which produce the largest quantity of hay. An invitation was issued by the State Committee in 1908 through the agricultural press to enter samples; these were to be grown on at least four of the six Experimental Stations, the seed to be sown two years in succession, under cover of a corn crop; the plants to be left growing for one, two, or three years, according to their character; the comparison to be between the yields of hay; the results to be published at the end of each series, giving names of the competitors. As far as space permitted samples could be entered by every Danish seed grower who had grown a strain during a series of years, or who had originated a strain or acquired the ownership of one, and who undertook to supply, free of cost, seed for two years, and give all desired information about the origin and history of his strain. At each station each sample was grown on five to seven, generally six, plots in the field. The resulting crops were cut, a first and a second cut each year, dried and weighed, as nearly as possible under the same conditions at each time and place.

Samples were entered of cocksfoot, Italian ryegrass, meadow fescue, meadow foxtail (*alopecurus pratensis*), tall oat grass, timothy, of early and late red clover, white clover, and birds' foot trefoil (*lotus corniculatus*), and cultivated together with trade samples from the localities abroad, whence the imported seed were generally derived, and also samples of many strains which had been improved by several years' cultivation at the Experimental Stations at Tystofte and Abed. The samples were sown in 1909 and 1910, to be reported on in 1913. So many requests to have other samples tested were received while this first competition was still being carried out, that

already in 1910 an invitation to enter samples for a second series was issued, and samples of cocksfoot, timothy, Italian ryegrass, and red clover were entered. The samples were sown in 1911 and 1912, under cover of a corn crop, to be harvested in 1912–13 and 1913–14. They were sown on five Experimental Stations on 6 to 12 parallel plots of from 12 to 24 square yards, and trade samples and samples of the strains from Tystofte were grown for comparison. The results were published in 1913 and 1915 in a report by E. Lindhard.[1]

In both series the Olsgaard strain gave the greatest yield of hay of all the samples of cocksfoot tested. It belongs to Kr. Rasmussen, of Højgaard, and is grown, as are all the best strains of the different kinds of grasses, by most of the seed merchants and associations of seed growers. Of Italian ryegrass a Tystofte strain, No. 152, was by far the best in both series. When seed of this strain was offered for sale—first time in 1912—the stock of seed, 12 cwts., was bought in 1 cwt. parcels in the course of a few days at a price of about £22 10*s.* per cwt.[2] by seed merchants and seed growers' associations, which proves that these felt confident that Danish farmers would be willing to pay a good price for seed of a specially good strain, as they had done with regard to strains of root seed. And in this confidence they were not mistaken, as already mentioned. Of meadow fescue the best strain was found to be one belonging to F. D. B., and known as Lyngby No. 9, having been improved by cultivation at the Co-operative Societies' farm at Lyngby. Tystofte No. 70 and 71 were the best early red clovers in 1909–12, but in the second series another strain, Vormark, was the best, with Tystofte 70 as No. 2. Of late red clover, a Tjæreby strain, was first in the first series, but came second in the second series, while Hersnap took the lead. Of white clover the Morsø strain was the best.

The result of these Comparative Cultivations of the plants of rotation grass fields, on the same principle as the Comparative Cultivations of different strains of the different kinds of roots,

[1] E. Lindhard, "Forsøg med danske og fremmede Stammer af Kløver- og Græsarter," I., 1909–1912, *Tidsskrift for Planteavl*, 20 vol., 1913, p. 169. And same, II., 1911–1914, *ibid.*, 22 vol., 1915, p. 365.

[2] Dorph-Petersen, l. c., p. 652.

was sufficiently encouraging to warrant a continuation. A new invitation was issued in August, 1913, the samples to be sown, as before, under cover of a corn crop, and each sample to be sown two years in succession and cultivated for two years, to estimate the yield of hay. Samples of cocksfoot, English ryegrass, timothy, meadow fescue, white and alsike clover, were sown in 1914 and 1915 and harvested in 1915–16 and 1916–17, while field brome grass, kidney vetch, and yellow trefoil were sown in 1915 and 1916 and harvested in 1916 and 1917. The samples were cultivated at seven Experimental Stations, each sample at four stations at least. On each station there were generally ten parallel plots of 24 square yards each. Besides the samples entered by Danish seed growers, some samples from Tystofte and some bought samples were compared in this, the third series. The results are given in a report by E. Lindhard.[1]

Nine Danish strains of cocksfoot were tested from D. L. F., F. D. B., Dæhnfeldt, Pajbjerg, Trifolium, Tystofte, and others. The best in regard to yield was again the Olsgaard strain ; the sample was bought from D. L. F. This strain, which was also the best in the two previous series, forms the greater bulk of the exported seed. Several of the other strains ran it very close, yielding only one or two per cent. less hay for the two years.

English ryegrasses were not tested in the two first series, but during the years 1879 to 1907 samples from Danish growers and from Scotland and Ireland had been compared for yield of hay with the result, that if the yield from Danish strains was taken as 100, that from Scotch and Irish were respectively 90 and 87.[2] The yields in 1915 and 1916 bear out this experience in so far as the best strain, the Lundbæk strain, entered by D. L. F., gave averagely for the two years 10 per cent. more hay than the Irish sample, which was bought from Trifolium, which firm had imported it from Ireland. Second was a strain, No. 20, from F. D. B., which yielded 5 per cent. more than the Irish sample. During the last year a Tystofte strain, No. 10, was included, which gave 4½ per cent. more hay than the Lundbæk strain,

[1] E. Lindhard, "Forsøg, etc.," III., 1914–1917, *Tidsskrift for Planteavl*, 25 vol., 1918, p. 117.

[2] *Tidsskrift for Landbrugets Planteavl*, 17 vol., 1910, p. 200.

which it resembles in early growth and endurance. The samples of ryegrass were sown on ten parallel plots of 24 square yards each, and the seed used was at the rate of 18 lbs. to the acre.

Three Danish samples of timothy were tested, two entered and one bought. At three stations they were sown together with two different strains of alsike, each sample of timothy sown at each station on four plots with each kind of alsike, therefore eight plots of timothy at each station. The proportion of timothy and alsike and of other plants was estimated by botanical analysis of the hay from each plot. On two of the stations were further ten parallel plots of timothy by itself. All plots were 24 square yards. When timothy and alsike were sown together $5\frac{1}{3}$ lbs. of each were used per acre; when timothy was sown alone 9 lbs. were used. The results from the different stations agree exceedingly well, and the two strains entered yielded very good crops, the best being "Trifolium No. 12" from the firm of Trifolium, but timothy 1913 from F. D. B. ran it very close.

Two samples of meadow fescue were entered by the firm of Dæhnfeldt, Odense, and compared with the best strains from the previous series, viz., Lyngby No. 9. The samples were sown at four stations. As meadow fescue is particularly useful on low-lying land, one of the fields selected for this comparison was a meadow and two were low-lying peat land. The samples were sown in mixtures with three different kinds of white clover, four plots with each kind, or twelve plots at each station, each plot of 24 square yards, the quantity sown being at the rate of 9 lbs. of fescue and $4\frac{1}{2}$ lbs. of white clover per acre. Unfortunately two of the selected fields, the meadow and one on peat land, were found to be unsuitable for the experiment, so that results were obtained from only two stations, showing Lyngby No. 9 was considerably the best on the field at Tystofte, while Dæhnfeldt's No. 5 exceeded it by 21 per cent. on the peat land at Herning.

Four kinds of Danish white clover were tested, together with a sample of Bohemian seed bought from Trifolium. They were sown with meadow fescue, as explained above, at Tystofte and at Herning on peat land. When, at the Comparative

Cultivations in 1909–12, Bohemian seed of the same origin as used in the third series was compared with the Danish strain, Morsø, both sown without admixture of grass, the Morsø strain yielded 30 per cent. more than the Bohemian seed. When grown with meadow fescue the Morsø strain yielded double as much hay as the Bohemian. At the competition in 1915–16 another Danish strain, Strynø, came out even better than Morsø, but is inferior in this respect that it does not give so much seed.

The two kinds of alsike, grown with timothy as explained, were one from Sweden and one from F. D. B. They were also sown on two stations without admixture of grass. Their relative yields were about the same, whether sown with or without grass. As new seed was used each year, the results from the two years are not comparable. One year the Swedish sample was the best, the other year the Danish sample.

One sample of yellow trefoil of Danish origin from F. D. B. was compared with a sample of English seed bought from Trifolium, and gave 13 per cent. greater yield of hay than the English sample. The experiment was carried on at three stations with 10 parallel plots of 24 square yards at each. The seed was sown at the rate of 16 lbs. per acre.

These Comparative Cultivations of grasses and leguminosæ of the grass fields are arranged on the same lines as those of the roots described in the preceding chapter. They are carried out as part of the work under the State Committee on Plant Culture, and managed by a Sub-Committee, consisting of the directors of all the Experimental Stations, with Mr. E. Lindhard as its very able chairman. Their aim is to find the best, most prolific strains of these plants, whether in Denmark or abroad, and to let farmers and seed growers know where to buy seed of these. The yield of hay on the fields of rotation grass will thereby be gradually increased, and the value of Danish grass seed will be improved. Only by an official and therefore unbiassed and independent tribunal like the State Committee carrying out these tests can a reliable result be secured. What was true of the Comparative Cultivations of roots is also true of those of grass seed, viz., that the large seed merchants, who at first were not favourably impressed by the idea of having their

seed controlled or judged, are now looking to these State Competitions as an indispensable aid to honest and genuine trade. These competitions have done away not only with the bad seed, but also with the dishonest and the ignorant seed merchants, and with them have disappeared the florid advertisements of indifferent strains with high-sounding names. The questions have been narrowed down to these: Which strain of roots gives the greatest yield of food-stuff or solids per acre? Which strain of grass produces the largest quantity of hay per acre?

This having been accomplished the next step was to ensure that the buyer received seed of the strain which he demanded. How this has been done and how a most remarkable reform has been brought about in the seed trade will be set forth in the last chapter.

CHAPTER IV

GUARANTEES IN THE TRADE IN SEED: (*a*) AS TO ANALYSIS BY THE SEED TESTING STATION OF THE STATE; (*b*) AS TO GENUINENESS OF THE STRAIN

THE development of the growing of root crops naturally had a strong influence on the trade in root seed and gradually also on the production of seed. In 1886 the total quantity of root seed required by Danish farmers was about 210 tons, while in 1915 it was estimated at 2850 tons.[1] This great increase is due not only to the very much larger acreage under roots, but also to the fact that much more seed was sown per acre. In 1886 all the seed sold was imported and sold as foreign varieties of the different kinds of roots. In 1915 it was almost exclusively seed grown in Denmark of Danish strains. In 1886 there was, naturally, no export of Danish root seed. From the year 1909 onwards the home-grown seed was about equal to the home consumption, and as the production gradually increased, there was a surplus for exportation. In 1915 about 2000 tons of seed of Danish strains of roots were exported, notwithstanding the difficulties due to the war. The export of root seed is expected to grow considerably during the next years.

It is thus only of late that the growing of root seed has attained to any importance. In 1896 the total acreage under seed of all kinds was only 9500 acres, and had by 1907 increased only to 10,400 acres,[2] of which 4500 acres were devoted to root seed. After that the acreage increased rapidly, especially that used for Swedes and Turnips, for which the Danish climate is particularly favourable.

[1] L. Helweg, "The Trade in Root Seed," Paper read before R. A. S. D. in March, 1916, *Tidsskrift for Planteavl*, 23 vol., 1916, p. 623.

[2] *Statistisk Tabelværk*, 5 Række, Litra C. No. 3, 1909, p. 33.

ACREAGE UNDER ROOT SEED, IN ACRES.[1]

	1907	1912	1916	1918
Mangels	1670	3240	2890	4930
Swedes	930	1630	2340	6050
Turnips	1900	2180	3280	7950

The system, long established in Great Britain, by which the production of seed is divided between seed merchants or seed improvers on the one hand who produce stock seed of improved strains, and farmers, seed growers, on the other hand, who grew this stock seed, generally on contracts with the owners of the strain, was gradually introduced into Denmark, and is now quite commonly practised there. Experts visit these growers to see that the roots are grown in a proper way, sufficiently far from other kinds of plants to avoid cross-fertilisation, in clean fields and under the proper agricultural conditions. These experts, or roguers, as they are called, also go over the fields and pull up all plants of suspicious characters. The total quantity of seed produced has to be delivered, in specified degree of purity, and is paid for according to analysis. Only in this way can seed merchants be sure of the kind of seed they offer for sale, and only in this way are they enabled to give that special guarantee which has now become not only commonly accepted but quite necessary in the Danish seed trade.

The history of the seed grower, Jens Hvidberg, reads like a fairy tale. Beginning life as a poor boy tending cattle, he was later on employed as a gardener to a farmer, and in 1893 started growing seed on one acre of land lent him by his employer. The next year he grew seed on four acres, and on one and two-thirds of an acre he harvested 18 cwts. of carrot seed which were sold for £150—a very substantial encouragement. In 1896 the acreage under seed was increased to 24 acres, and in 1898 Jens Hvidberg bought the farm "Pajbjerg," of 185 acres, from which the large firm, to which the business has now grown, derives its name. A few years before Hvidberg moved

[1] *Statistiske Meddelelser*, 4 Række, 57 Bind, No. 3, p. 76.

to Pajbjerg he bought a cartload of swedes from a farmer on whose farm he had noticed a particularly fine crop. After they had been carted for nine miles in a sharp frost most of the roots were found to be frozen, and only about thirty roots grew to seed. From these roots descend the Pajbjerg swedes which were entered at the Comparative Cultivations in 1900. They came out in Class I., and at every competition since then this strain has maintained its position as a first-class swede.[1] Another strain of Hvidberg's is a Yellow Tankard turnip, originally evolved from seed from P. Lawson and from Markfrøkontoret (now Trifolium), Copenhagen. This strain obtained a Class I. certificate in 1902 and has since maintained that position, and other Yellow Tankard strains in Class I. have been derived from the Pajbjerg strain.[2] Some years ago the firm, which owns several farms and branches in various parts of the country, with large warehouses, was converted into a joint stock company, "Pajbjerg, Ltd.," with J. Hvidberg as its chairman and its headquarters in Copenhagen.

In olden time the Danish seed trade had been characterised by Chr. P. Jacobsen as "the lawlessness of ignorance." E. Møller Holst founded his seed testing office in 1871, and the next year Jacobsen and others invited farmers to participate in the joint purchase of analysed seed, and so formed the Markfrøkontor, the first firm to deal in analysed seed, and now known as Trifolium. Since then the control of the trade in seed has been developed considerably. When in 1891 the Seed Testing Station was taken over by the State only 1600 samples were tested annually, and during the next twelve years the number increased very slowly. Seed merchants and farmers then began to see the necessity of giving or of obtaining some guarantee as to the quality of the seed, its purity and germination, and more samples were sent in for analysis. By 1907 the number had increased to 4200, by 1911–12 to 11,500, and in 1918–19 the number was about 24,400. This large increase is due partly to the largely increased acreage under seed crops, seed merchants, seed growers and their associations sending in

[1] L. Helweg, Report, *Tidsskrift for Planteavl*, 17 vol., 1910, p. 262.

[2] *Vor Frøavl*, January, 1919. These strains have been mentioned several times in the second chapter.

many samples of seed to be sold, while farmers and their associations send in samples of seed delivered in order to learn whether the seed complies with the guarantee as to purity, germination, and so on, under which they were bought. The increase is also due to the fact that many seed dealers now sell their seed to farmers or to societies of farmers, subject to a scheme worked by the State Seed Testing Station, according to which analyses of samples, sent under certain conditions as to sampling after delivery, are made and published by the Seed Testing Station. Twenty-one firms and associations dealing in seed and selling an aggregate quantity of seed corresponding to two-thirds of all the seed used in Denmark, have now submitted themselves to this control. "It is safe to say," writes the director of the Seed Testing Station, K. Dorph-Petersen, "that there is no other country in the world where the control of the seed used by the farmers is so extensive and so careful. The results are not accomplished under the pressure of the law, but by the mere voluntary co-operation of those interested." [1]

This so-called "automatic control" aims at investigating whether goods delivered by the dealers, subjecting themselves to this control, correspond to the guarantee given to the buyer as to purity, maximum proportion of weed seed, germination, and so on, or whether the goods are so much below the guaranteed quality that the purchasers may be entitled to compensation or reduction in price, according to the rules of the Seed Testing Station. The control is carried out by the Seed Testing Station which, by an agreement with the seed merchants in question, assumes a control of all seed delivered, during the season, under the guarantee given by the merchants to farmers, their societies, to retailers or to co-operative stores. The merchants must inform the Seed Testing Station of the guarantees under which they have sold their seeds during the season, and must at the time of delivery submit to the Station the addresses of all home purchasers of these seeds, stating the amount and variety of seed and the guarantee under which

[1] Pamphlet published on the occasion of a visit by a British Seed Commission, and a visit by Australian farmers, to the Seed Testing Station in July, 1919.

the seed was sold. A few addresses are chosen at random, having regard to the number and size of the consignments, and to these customers the Seed Testing Station writes asking for samples of one or more of the consignments of seed received by them. Double paper bags are sent with the request, the inner bag bearing printed rules for taking samples and a declaration to be signed by the customer and witnesses. The Seed Testing Station also draws samples at the merchants' warehouses from stock seed ready for delivery and seals these with the seal of the Seed Testing Station. The samples are tested for purity, germination, proportion of weed seed, and so on. Each year a full explanation is printed and distributed showing the conditions under which the scheme is worked, the maximum percentage deviation ("latitude") allowed from the guaranteed purity, germination, proportion of weed seed, weight of corn, and so on, how the compensation is calculated which may be due to the buyer, in which cases the buyer may refuse delivery, in which cases the question of compensation, generally fixed by the Station and accepted by both parties, may be left to the decision of the Courts, and so on.

The result of the analyses of samples of their goods is communicated to the various firms, and at the close of the year a summary is drawn up showing for each firm separately the result of the analyses of all samples taken from their shipments, the deficiency in purity and germination entitling buyers to compensation, and the amount of compensation in percentage of the price of the consignments. Each firm sending in samples will receive a copy of this summary with full explanations, and the firm is under obligation to communicate to all who have bought their seed under guarantee the result of the analyses of their seed, and to send to the Seed Testing Station a signed declaration that they have done so. The correctness of this declaration is tested by means of an enquiry from the Station to some of the customers as to whether they have received the information and the compensation to which they are entitled under the Rules of the Scheme. Annual reports are published in *Tidsskrift for Planteavl,* giving summarised details of this "automatic control."

The following figures have been culled from the report for

the year 1915–16.[1] The total number of analyses of samples from consignments sampled after delivery was 2186. The number of samples showing that the buyer was entitled to compensation, on the ground that the deviation exceeded the limit fixed, was :—

Number of samples showing deficiency in purity of :—

Per cent. :	2–3	3–5	5–8	8 or more.
Numbers :	32	23	16	4

Number of samples showing deficiency in germination of :—

Per cent. :	3–4	4–6	6–9	9 or more.
Numbers :	6	22	39	46

Of these 2186 samples 1586 were derived under the " automatic control " from consignments from thirteen named firms or associations. For some of these consignments, however, no guarantee had been given. In the case of 1504 samples the purity had been guaranteed :—

	Number.	Per cent.
Equal or superior to the guarantee were	995	66
So much below the guarantee that compensation was due to buyer were	42	3

In the case of 1420 samples the germination had been guaranteed :—

Equal or superior to the guarantee were	950	67
So much below the guarantee that compensation was due to buyer were	77	5
Total number of samples for which compensation was due . .	112	
Percentage of the total quantity of seed delivered and controlled for which compensation was due		2·92

By six named firms of the thirteen a guarantee had been given as to the maximum proportion of weed seed. 635 samples were tested, and of these twenty-four samples were found to contain so much weed seed that compensation was due to buyer.

Three of the (named) firms had no samples deficient in purity ; four firms had no samples deficient in germination ; one of the firms had no deficiency in either respect. One

[1] Report from the Seed Testing Station of the State, 45th working year, *Tidsskrift for Planteavl*, 23 vol., p. 785.

(named) firm showed an appreciable deficiency in both respects. The total quantity of seed controlled that year was 92,955 cwts.; 2712 cwts. were found deficient, but most of the compensations due were small. A full list of the percentages of purity and germination by each of the thirteen firms for each of the twenty-seven kinds of seed is also given.

It is interesting to see, in the same annual report, the result of analyses of samples bought from farmers all over the country, of parcels of seed from smaller and larger firms who seldom or never subject themselves to a control such as the one just explained. The samples were procured by the officers of the large Provincial Associations of Agricultural Societies. In all 378 samples of nineteen different kinds of seed were sent in to the Seed Testing Station. In the case of 134 samples the firms had stated the purity and germination which they guaranteed, in the case of the remainder it was assumed that the seller had guaranteed a purity and germination equal to the averages of all samples tested in the previous year. The results are grouped like those of the 2186 samples mentioned above. The figures below show the number of samples showing deficiency in purity of :—

Per cent. :	2–3	3–5	5–8	8–13	13 or more.
Numbers :	21	35	23	14	11

and the numbers of samples showing deficiency in germination :—

Per cent. :	3–4	4–6	6–9	9–15	15–30	30 or more.
Numbers :	2	27	27	47	34	17

In 104 samples, or 28 per cent., the deficiency in purity was such that the purchaser should have had compensation, and in 154 samples, or 41 per cent., the same applies to the germination test. In all 195 samples, or 52 per cent. of the total number fell short of the quality of ordinary good seed, while only 3·5 and 5·2 per cent. of the samples taken under the scheme of automatic control were deficient in purity and germination respectively. Many of the 378 samples contained many more seeds of weed than generally found. In 1915–16, therefore, there were several farmers so negligent that they would buy inferior, impure

seed of low germination. But the publication of these reports naturally has the result of improving the trade and of bringing to the fore the reliable and conscientious firms, and, as stated, in 1918–19 two-thirds of all the seed used in Denmark were fully guaranteed, and nearly all of these consignments were up to a very high standard. From the season 1919–20 the firms submitting to the automatic control must guarantee all the seed of grasses, leguminosæ and roots they sell, both as to purity, maximum contents of weeds, and germination.

The automatic control has, so far, aimed at the protection of buyers of seed for use in Denmark, but there would be no hindrance to the extension of the control so as to make it apply equally to the protection of buyers outside of Denmark, should they so desire.

As Dorph-Petersen truly says, this result, the extensive use of official analyses of seed both by merchants and farmers, has been accomplished under no legal or administrative pressure, but voluntarily, and because both parties to the deal in seed have found it to their distinct advantage to gain exact knowledge of the character of the goods they are selling or buying. An attempt was made, however, at a fairly early stage of the development, to prescribe legal regulations for the trade in seed. In 1896 a Bill was laid before the Danish Rigsdag by the then Minister of Agriculture, dealing with the trade in manures, feeding stuffs, seed corn, and seed. It required the seller of these goods to deliver to the buyer, not later than at the time of delivery, a written declaration (for instance, on the invoice or sale contract) giving, with respect to seed, the following information: Name or firm of seller and buyer; name of the goods, indicating variety, strain, locality where produced, all according to the trade custom at the time, and if a mixture, this must be stated; the percentage of purity and germination according to the rules of the State Seed Testing Station, with the amount of deviation allowed; the weight of 1000 grains in grammes. The seller should sign this declaration and be responsible for its correctness. The packing should bear a label, attached or enclosed, stating plainly the name of the goods. The buyer, having received such declaration, should be entitled to send for analysis at the Seed Testing

Station samples taken in the presence of both seller and buyer as fully described in the bill. Should the goods be deficient in quality the buyer may refuse to take delivery or may claim compensation, and if the parties cannot agree, the matter may, if the seller has so stipulated at the time of sale, be decided by arbitration according to rules stated in the Bill.

It was perhaps not unnatural that a very strong protest against this proposed legislation should come from the part of the merchants, who among other arguments objected, that if all consignments were to be equally guaranteed under Law there could be no incentive for buyers to purchase from the more reliable firms, but that less scrupulous firms would gain an advantage, and that there was no necessity whatever for the legislation, as good firms already offered sufficient guarantee to buyers. The Bill became Law as far as manures and feeding-stuffs are concerned,[1] but the parts dealing with seed corn and seed were left out. It is curious to notice that the principal agricultural paper, *Ugeskrift for Landmænd*,[2] anticipated that the cost to the State of controlling the trade and of carrying out the necessary number of analyses would be very great, and that the Minister of Agriculture mentioned during the deliberations in the Rigsdag, that, presumably for the sake of economy, the State could not undertake the control, but that this might be done through the Agricultural Societies. In 1895 the Seed Testing Station had analysed 1500 samples. The *Ugeskrift* estimates that at least 2000 more samples must be analysed annually, which it thinks would be rather costly. Compare with this the fact that the Seed Testing Station last year analysed 24,400 samples, and is now very nearly self- supporting! But even more gratifying is the fact, already stated, that the control of the trade, which the agricultural party wished to introduce by legislation, has been established without legislation, and at the same time avoiding the objection raised by the merchants, that the less scrupulous firms would benefit when the trade of all was subjected to the same control. The voluntary control now practised is a distinct advantage not only to the farmers but to all high class firms.

[1] *Law on the Trade in Manures and Feeding Stuffs*, of 26th March, 1898.
[2] See that weekly paper, 1896, p. 635.

It will be seen that the Bill went rather further than the "automatic control," in so far as it required the seller to guarantee not only the variety but even the "strain," that is, not only those characters of the samples which can be estimated by an analysis but those inner, inherited characters of the seed which an analysis is unable to reveal, but which only appear when the seeds are sown and the plants grown to full development, those characteristics, in fact, which make certain strains more productive and otherwise more useful than others, and according to which the awards at the Comparative Cultivations of roots are given. It was, I believe, fortunate, that a legislative attempt to protect the "strains" as early as the year 1896 was not carried through, because at that time the full understanding of the meaning of "strain" was far from common property. It might have spoiled the development if it had been forced. In the following pages we shall see how all and more than all of what was aimed at by the Bill of 1896 for the protection of the buyer of a special strain has been gained by voluntary action, under Helweg's firm, unremitting and clear guidance. When the merchants in 1896 thought they were then giving sufficient guarantee they little dreamed of what they or their successors would be doing, and doing voluntarily and gladly, twenty years later. It has been repeatedly stated of late years by the leading seed merchants, that without the guarantee of the strain, as now almost universally given, no respectable and high class trade could be carried on nor be protected against undesirable and inferior competitors. The security which the Bill of 1896 proposed for the farmers is now looked upon as a security for the merchants. To explain how this has been brought about will be the aim of the next pages.

In "the good old times" anybody could deal in root seeds without even knowing how the roots looked. It was enough that a dealer bought seed of some variety of roots from abroad or from a Danish merchant who had imported it, he could then offer it to farmers under the name of the variety. And there were then many varieties in the market. Few merchants and still fewer farmers troubled about the purity or germination of the seed, still fewer had any idea of what yield of roots the

seeds were likely to give or what they ought to give. The trade as a rule was hampered by no such consideration. Then came in the seventies the reform introduced by Chr. P. Jacobsen on the strength of E. Møller Holst's seed testing, and gradually the idea that the seed ought to have a certain germination and purity gained ground. But while this was sufficient for most kinds of seed, and was gradually developed as already explained, it was far from sufficient for root seed ever since the Comparative Cultivations, carried out by Helweg on behalf of the State Committee on Plant Culture, had proved that some strains yielded a much larger quantity of food for cattle than others. Then it became a question for the farmers to secure seed of such strains, and it became a question for the merchants to supply seed of these strains. Of course, it took years to educate the farmers to see the importance of this new development. The first stage was reached when farmers asked for seed which yielded a large crop of roots, but Helweg pointed out in his reports as early as 1891, " how senseless " it was of farmers to look only for a large crop without asking what the roots contained of dry matter, of nourishment for their cattle, and he called upon farmers to " demand from seed growers analysis or guarantee of the food-producing character of the seed they bought." Such a guarantee could only be given when the origin of the seed was known, when, that is to say, it was known that the seed was produced from roots of a strain which by the Comparative Cultivations has been found to be a Class I. strain, one of those which yielded the highest amount of food-stuff per acre.

A son of Chr. P. Jacobsen—J. E. Jacobsen—was manager of the seed business of the F. D. B. (the Danish Co-operative Wholesale Society), and to him belongs the honour of having in 1906 introduced into the trade in root seed the Guarantee of Genuineness, the guarantee that the seed is of the strain stated. The guarantee of purity and germination is decided by the analyses of the Seed Testing Station, the guarantee of genuineness, as now developed, is decided by Helweg, as the Root Seed Commissioner of the State. Leading firms subsequently adopted this new feature in the trade in root seed, and they could do it for such seed as they produced themselves,

or which they had grown for them by seed growers from stock seed supplied by the firms. But naturally some firms lacked the means or the ability to accommodate themselves to the new conditions. Much seed was still sold of which neither the seller nor the buyer knew the origin, and many farmers were still willing to buy seed if only it was cheap without realising the loss arising from the smaller yield of food-stuff resulting, which in most cases was many times greater than the saving effected by buying cheap seed.

But it also happened that merchants sold seed under incorrect names or false trade descriptions, or sold seed stating it to be of a certain strain which it was not, and in some of these cases claims for compensation were raised which were decided by the Courts. In a series of annual reports on the " Harvest of Root Seed and the Trade in Root Seed," written by Helweg and published in *Tidsskrift for Planteavl*, as also in his previously-quoted paper read before the Royal Agricultural Society of Denmark in 1916 and published in the *Tidsskrift* of the same year, Helweg has given much information about these law cases and about complaints from farmers of bad seed. These reports have served as a useful guide to both buyers and sellers, and have materially helped to evolve the perfect system of guarantee now commonly practised.

A Danish Law of 27th April, 1894, makes it a punishable offence to use a false trade description in connection with goods sold or for sale, and a Law of 20th March, 1918, superseding the former, deals with unfair competition and false trade descriptions. Under the former Law several cases were decided in which seed merchants had to pay farmers compensation for selling seed which was not as represented. One merchant had to pay a compensation of £350 for inferior seed of turnips, while another who had sold seed of swedes but delivered rape-seed, which was only discovered when the plants grew up, had to pay the farmer £13 10*s*. per acre. From 1904 many seed merchants had undertaken to refund the money paid if seed delivered was not as stated. But, as Helweg pointed out (Report, 1911), the loss suffered by the farmer was many times larger than the amount of the invoice. The Society of Wholesale Dealers in Root Seed, formed in 1904, at the instigation

of Chr. Dæhnfeldt, who was the chairman until 1915, took occasion from the above-named law cases to advise its members to have printed on their invoices and other trade paper a clause to this effect: "No compensation beyond the amount of the invoice is given for defects in root seed due to faulty production or for mistakes in filling the order." This clause was generally adopted from 1905 and onward.

A retailer had sold 20 cwts. of mangel seed to farmers who found the resulting root crops so bad that they claimed compensation, and the retailer paid them £300. He then sued the wholesale firm to repay him this amount, but the Court found in 1910, that although the seed was undoubtedly bad, the wholesaler was protected by the above clause, and decided that the retailer was only entitled to the amount of the invoice, or £35.

It was, however, not only because of the clause that the wholesale firm was let off so cheaply. Even without the clause, it was the custom in the wholesale trade in root seed to refuse to pay compensation for faulty seed or for errors in filling the order, beyond the amount of the invoice. And a Law on Purchase, of 6th April, 1906, gives its sanction to such trade customs. Sect. 43, third paragraph, of that Law provides that the seller of goods of certain kinds (goods the quality of which is determined by their special kind, for instance, root seed of special strains) is liable to pay to the buyer compensation for faults or defects in the goods, even if he is blameless, that is, even if the defect is not due to any remissness on his part. But Sect. 1 of the same Law provides, that the provisions of the Law shall only apply in case no other conditions of sale have been stipulated, or must be considered as implied in the conditions of sale, or form part of the custom of trade or other custom. As it was the custom of the trade in root seed, that is to say the wholesale trade, to pay no compensation beyond the amount of the invoice, it follows that retailers could claim no compensation beyond the amount of the invoice unless the wholesale firm expressly agreed to pay a larger compensation, and this they were careful not to do.

But the retailer was, according to custom, and according to several legal decisions (by the High Court in 1888 and

1902) liable to pay to the farmers compensation for seed sold, amounting to the difference in value of the crop resulting from the seed delivered and of the crop which would have resulted had the seed been of the kind which the buyer had demanded and which the seller had professed to deliver. The compensation, fixed by inspection in the field by experts, was sometimes twenty or thirty times the amount of the invoice.

There is another proof that the retailer was obliged to pay full compensation to the farmer, a proof which incidentally shows the truly remarkable trust both farmers and dealers put in Helweg, and which was fully deserved by his integrity and his enthusiasm in seeing justice done and progress made in all that concerns the cultivation of roots. When he pointed out in his annual reports on the trade in root seed that not unfrequently seed was delivered to farmers which produced £2 less value of roots per acre than if the seed had been of the strain which it professed to be, farmers came to him with their complaints. For a number of years he was called upon every autumn to inspect root crops, and when he found that they were not of the strain professed, he fixed the compensation which he deemed due to the farmers. And the retailers paid the amounts claimed. Helweg concludes, not without good reason, that had the retailers thought they could avoid payment by going to Court, or that they would have been let off with a less payment, they would surely have tried that procedure. If they did not, he concludes that their solicitors had advised them rather to pay the compensation fixed by him.[1]

There had even been at least one case where a dealer had wilfully altered the labels in the bags of seed. He had bought seed which was described as "similar to Sludstrup Barres"; he removed the labels with this inscription and replaced them by labels stating the seed to be "Sludstrup," a strain then bearing a Class I. certificate from the Comparative Cultivations. This was a fraud, and the dealer was punished by imprisonment under Sect. 251 of the Penal Code.

By the beginning of this century the trade in root seed had begun to recognise the "strains" and to offer seed of the

[1] *Tidsskrift for Planteavl*, 23 vol., 1916, p. 640.

various strains which had been placed in Class I. at the Comparative Cultivations. By the year 1916 root seed of a variety, without mention of the strain, had become almost unsaleable. While it is easy to recognise the different varieties, by their shape, colour and other external features, it is difficult to recognise the different strains of the same variety, as their external characteristics do not differ very much; the difference is found in the different yield when grown under similar conditions.

Since the year 1910 almost all root seed used in Denmark has been of Class I. strains of Danish production. But while seed merchants sold seed of Class I. strains they were careful not to guarantee that the seed was of the strain it professed to be. Most merchants had on their invoices and other trade documents a clause stating that they gave no compensation if the seed should be found to be different from what it was stated to be when sold. The Danish seed merchants were not peculiar in this. Most seed merchants in other countries did the same, and do so to the present day. In England, America, New Zealand and elsewhere a clause such as the following is in common use: "We give no warranty, expressed or implied as to description, quality, productiveness or any other matter of any seed we send out, and we will not be in any way responsible for the crop. If the purchaser does not accept the goods on these terms they are at once to be returned." As far as Great Britain is concerned, this has been altered by the Seed Order of 1917, but only so far as the analysis thereby required. The description of the seed, the productiveness, the yield of the resulting crop, for root seed especially the genuineness of seed as to strain, are all matters about which no warranty is given.

As has already been said, J. E. Jacobsen, of F. D. B., had in 1906 introduced in the seed trade the Guarantee of Genuineness, that is to say, that the F. D. B. when selling root seed gave a full warranty that the seed was of the strain stated, and that the F. D. B. took full responsibility for the productiveness of the seed, guaranteed that the resulting crop of roots would be of the strain stated, yielding the amount of food-stuff per acre which the circumstances as to the soil, mode of cultivation

and the weather warranted. This was a distinct step forward, a new departure in the trade in root seet, a result so to speak of the Comparative Cultivations. It was, of course, only possible for F. D. B. to give this guarantee because they had the seed they sold grown under inspection from stock seed supplied by themselves. But many other seed merchants dealt in seed produced by or for themselves from stock seed of strains tested by the Comparative Cultivations at the Experimental Stations as described above. These other firms were, therefore, in a position to give the same warranty as given by the F. D. B. But it required a broad-minded merchant to take the plunge, so to speak, of going against the universal custom of seed merchants and to undertake a guarantee for genuineness of strain in root seed. This man was Chr. Dæhnfeldt, of Odense. His father was a well known gardener there ; the son extended the business, took up the cultivation of horticultural and other seeds on a large scale, improved several strains, also of root seed which came in Class I. at the Comparative Cultivations, gradually developed an extensive export business in seed of all kinds, and is now growing commercially different kinds of flowering bulbs and other cultivations new to the country. The firm has been converted into a joint stock company, L. Dæhnfeldt, Ltd., Odense, and is the largest of its kind in Denmark. In 1904 Chr. Dæhnfeldt had formed the Society of Wholesale Dealers in Root Seed for the mutual protection of their interest, the members of which agreed to refuse compensation for faulty production beyond the amount of the invoice. In 1912, Dæhnfeldt, who was still the chairman, induced the Society to adopt the Guarantee of Genuineness in the trade in root seed, and in the spring of 1913 root seed was offered for sale under seal with a guarantee that it was of the strain indicated, and that full compensation would be given to the buyer for the smaller yield resulting if it should be found that seed of another and inferior strain had been sold. This applied to seed of mangels, swedes, turnips and carrots. Under legal form samples were drawn from every consignment of root seed sold in 1913 with this guarantee, the samples were sown by the Root Seed Commissioner of the State, Helweg, in control fields in order to be able in the autumn to decide, from inspection

of the crops in these control fields, whether the seed was what it professed to be.[1] In the autumn several complaints came from the farmers who had purchased seed, but few of these were substantiated. By far the greater number were found to be unjustified. If roots in the farmers' fields gave a low yield, were forked or ran into seed but at the same time the sample grown in the control fields showed none of these faults, it was thereby proved that the cause was faulty cultivation or attacks of pests or fungi and not faulty seed. This is, of course, of the greatest importance to the retailer selling seed bought from a wholesale firm under its seal. If complaints are raised and if they are proved to be due not to the cultivation but to faulty seed, then the wholesale firm must pay the retailer full compensation as paid by him to the farmers. If, on the other hand, the complaints are unjustified, which can be proved either by having a sample of the consignment grown in a control field or by comparing with the crops of other farmers resulting from seed of the same stock from the same firm, there will be no compensation to pay. But the wholesale firms also are interested because they are protected against an abuse of which there had been some instances both before and in 1913. A retailer might buy seed from a wholesale firm and might advertise that he sells that firm's seed. But he might also buy cheaper and inferior seed elsewhere and pass it off as seed of that firm, which might injure the reputation of the firm. Most large, respectable wholesale houses, therefore, adopted the guarantee of genuineness for all such seed of the origin of which they were sure, such as was produced by or for them from their own stock seed. But firms who bought cheap seed from anybody could not follow this new reform, could not guarantee the strain, and soon came to be regarded as unreliable.

It might here be mentioned that by a decision in a High Court, supported by an official declaration by the Merchants' Guild of Copenhagen, stock seed is a legally recognised term, and the selling of trade seed as if it were stock seed is a punishable offence. If, therefore, a dealer sells seed with a guarantee of genuineness relying on the fact that the seed has been

[1] L. Helweg, "Reforms in the Trade in Root Seed," in *Ugeskrift for Landmænd*, 1914, p. 514.

produced from stock seed which he has bought, and if it turns out that the seed he sold is not genuine, and is either not of the strain stated or has degenerated because produced from ordinary trade seed, he can get compensation from the man who sold him as stock seed that which was not stock seed.

By the year 1916 about half the acreage under root was sown with seed bought with a guarantee for genuineness, that is to say, seed of Class I. strains certified as such by the directors of the Experimental Stations under the scheme of the Comparative Cultivations. The majority of the wholesale houses gradually carried the reform through to its logical conclusion, and now deal in no seed for which they cannot give a guarantee, and so sell all their seed under seal and with a full guarantee, that is, as explained, guaranteeing the crop to be of the strain stated and yielding as the strain would and should.

In his report on the trade in root seed in the year 1913 [1] Helweg mentioned some cases of sale of inferior seed sold as Class I. seed. Since then there have been no such cases. The risk has proved too great. Cases there have been and will probably always occur of errors made in filling orders. For such the dealers will pay compensation. In his report on the trade in 1917, after stating that no bad root seed has been sold in Denmark since 1913, Helweg says: "We have come to this state, that no seed merchant dare sell bad root seed in Denmark. . . . Some among the old seed merchants considered it an interference in the free trade in seed that farmers should be compensated if the seed was not what it was represented to be. But it did not last long before respectable seed merchants understood, that a better weapon in the competition with the unreliable trade [than the Laws above referred to] could hardly be imagined." [2] Frequent expressions by seed merchants at meetings and in the Press confirm this. The sale of seed under seal with full guarantee of genuineness is a reform fatal to all unreliable trade.

The success of the latter reform, introduced in 1906 by the F. D. B. and commonly adopted by the Society of Wholesale

[1] *Tidsskrift for Planteavl*, 21 vol.

[2] L. Helweg, "Report on Harvest of and Trade in Root Seed, 1917–18," *Tidsskrift for Planteavl*, 25 vol., 1918, p. 558.

Dealers in Root Seed by a resolution in 1912, was so great that the Society decided the very next year to extend the guarantee also to customers abroad, to sell seed for export under seal with the same guarantee of genuineness. To make this effective required some co-operation with officials, which was readily given. The working of the scheme, as far as the export trade in root seed from Denmark is concerned, is described by circulars sent by the exporting firms to their customers abroad and drawn up in concert with Helweg :—

When a consignment of seed is ready for export a label giving the name of the variety and of the strain and the number of the consignment is placed in each bag. The seller then calls in the Royal Danish Weigher (a sworn official), or any other person authorised to draw samples, to draw a sample of 1 kg. ($2\frac{1}{5}$ lb.) of the consignment according to the Regulations for Sampling of Seed (see below), this sample to be used to test the genuineness of the consignment. Having ascertained that the labels in all the bags are identical the sampler will seal all the bags with his official lead seal at the same time likewise sealing the sample bag containing the 1 kg. sample. The sample bag he will send to the Danish Government Root Seed Commissioner, 8, Akasiavej, Copenhagen V., together with a declaration as mentioned below.

In the spring the Government Commissioner will sow, in two experimental fields, all the samples of seeds received from the various samplers. If complaints should be raised during the following autumn respecting a consignment of seed exported in the spring an inspection of the roots grown in the experimental fields from the official sample of that consignment will show, in such a manner that evidence on the point can be given in a Court of Law, whether the seed in question had been correctly named or whether it was inferior to genuine seed of the strain named on the label, to such an extent that the purchaser has a just claim to compensation.

These claims from customers should be sent by registered letter to the Government Commissioner, 8, Akasiavej, Copenhagen V., in time to be delivered to him before October 15th. A certified copy of the seller's invoice must be sent with the claim.

When the Commissioner has received a complaint from a buyer he will inspect the roots in the experimental fields grown from the sample drawn from the consignment in question. If he thinks there is any reason for complaints he will send to both buyer and seller his estimate of the compensation per kg. seeds which should be paid. The amount of compensation should, if possible, be settled between seller and buyer direct or failing this it should be settled by arbitration. Should the parties fail to agree to have the matter

decided by arbitration the question of compensation will have to be brought before the Court by a law-suit at the "Sø- og Handelsretten" (Maritime and Commercial Court) in Copenhagen as proper venue, before which Court both seller and buyer must appear in person or by properly authorised representatives, there to attempt an amicable arrangement, or, failing this, to receive the final decision of the Court. The said Court will decide the amount of compensation according to the rules in force in Denmark at the time and with due regard to the character of the crop grown in the experimental fields.

The regulations for drawing samples of root seed for export are as follows :—

A small sample is drawn from each bag, alternately at the top, in the middle and at the bottom of the bag. If the consignment consists of less than 10 bags a sample should be drawn from each bag. In case of larger consignments samples must be drawn from every fifth bag, and in no case from less than 10 bags. In case of consignments of more than 200 bags samples must be drawn from at least 40 bags.

The smaller samples drawn as described must be carefully mixed and from the mixed sample so produced 1 kg. ($2\frac{1}{5}$ lb.) of seed is packed in a sample bag and four smaller samples, weighing 100 grammes (about $3\frac{1}{2}$ oz.) each, in smaller bags. The sampler will then close with his lead seal both the samples and all the bags of the consignment.

He will send the 1 kg. sample to the Government Root Seed Commissioner, 8, Akasiavej, Copenhagen V. The exporter will send one of the four smaller samples to the purchaser, one he will keep himself, and the remaining two he will send to the Seed Testing Station of the State, Bülowsvej, Copenhagen V. The Seed Testing Station will at once test one of the samples for purity and germination, and will keep the other for further reference in case either the seller or the purchaser should require further tests to be made. The two samples sent to the Seed Testing Station shall serve as material for the analysis of the consignment, and analyses of other samples of the consignment shall not be considered by either seller or buyer.

The Sampler must then sign the following declaration in three copies :—

This is to certify that I have this day, at the request of..... (name and address of exporting firm), drawn one sample of 1 kg. and four samples of 100 grammes each, being representative samples, drawn according to the regulations for sampling, out of a consignment of..... bags. In each bag was a label bearing the following inscription.....

.....(a complete copy of the inscription on label).

After the sampling was finished each bag of the consignment was closed with my official seal and with the guarantee seal of the firm. The 1 kg. sample sealed with my seal I have this day sent to the Government Root Seed Commissioner together with a copy of this declaration, the remaining two copies together with the four smaller samples I have handed to the exporters, Messrs.....
.....

(*Signed*)

Name of Official Sampler.

Date.....

The exporting firm will, as stated, attach their own seal to all the bags as a proof that they guarantee the genuineness as to variety and strain of the seed according to the description on the label in each bag. This shall apply to all seed of mangels, swedes, turnips and carrots sold by the firms to foreign customers, and shall be a guarantee that the seed is from strains awarded a Class I. certificate by the Comparative Cultivations as described in the second chapter, carried out at the Experimental Stations of the State. And this guarantee, making the exporter liable under the Danish Law on Purchase, of 6th April, 1906, shall be accepted, in the form stated above, as a condition of sale of all seed sold with the seal of the exporter.

The German Ministry of Agriculture is so fully alive to the importance of having the fields sown with good seed, and it appreciates the value of the guarantee of genuineness described above to such an extent that it has prevailed on the Commissioner for Import and Export to permit the import of root seed from Denmark only provided it has been bought under this guarantee.

The guarantee of genuineness which at present is in use only in the trade in root seed will during 1920 be extended also to the seed of grasses and the leguminosæ of the rotation grass field. It should, however, be understood that, in addition to the Guarantee of Genuineness, the seed of roots is also sold, like seed of grasses, with a guarantee of purity, germination and other characters as determined by the analysis of the Seed Testing Station of the State.

The root seeds so far mentioned are those of mangels, swedes, turnips and carrots, seeds of roots used as fodder for cattle and pigs. During the last years the growing of seed of sugar beets has been taken up in earnest; like so many new developments, this is a result of the disturbing influences of the world war. The cultivation of sugar beets, as already mentioned, has for many years been of great importance in Denmark, where enough sugar has been produced for the country's need with even sometimes a surplus for export. But the industry being chiefly in the hands of one large company which made contracts with farmers for growing beets for the various factories and supplied them with the seed which the company bought in Germany, there was no growing of seed of sugar beets in Denmark before the war. When the war made it difficult and later on impossible to get seed from Germany, the growing of seed was started and experiments made of how best to grow it. It was soon found that the soil and the climate were particularly favourable for this cultivation, and that large crops, averaging 24 cwts. per acre, could be grown by very cheap methods such as had been in use for growing of seed of swedes. Either the seed is sown in the spring under cover of a corn crop or in late July on fallow land, with a distance of 70 cm. (27½ inches) between the rows. In the autumn the earth is hoed up to the rows from both sides, and in March the plants are freely manured with nitrates or liquid manure.

For the profitable cultivation, that is for obtaining large crops of seed by a cheap method of cultivation the climate is of paramount importance. The temperature during the months from May to September must not be too low, or the seed does not ripen. Neither must it on the other hand be too high nor the rainfall too low. The temperature during the months from November to March must not be too low—a single month with a minimum temperature of —10° C. (14° F.) is fatal to the method of cheap cultivation described. From this it follows that the districts in the various countries where this cultivation can be successfully carried out are very much restricted. But happily for Danish farmers the necessary conditions are found in the greater part of Denmark. For this reason it is expected that the cultivation of sugar beet seed in Denmark will attain

to great proportions during the next years, and that a large export of this seed at comparatively low prices will take place. The experience gained by Danish growers and the excellent organisation of both production of and trade in seed should be a material help to realise this new aim of Danish seed growers.

THE END

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