The Culture and Manuring of Fodder Crops

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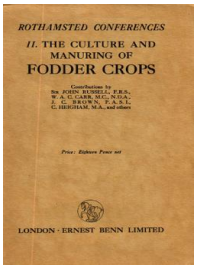

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ROTHAMSTED CONFERENCES

II. THE CULTURE AND MANURING OF FODDER CROPS

Contributions by
SIR JOHN RUSSELL, F.R.S.,
W. A. C. CARR, M.C., N.D.A.,
J. C. BROWN, P. A. S. I.,
C. HEIGHAM, M.A., and others

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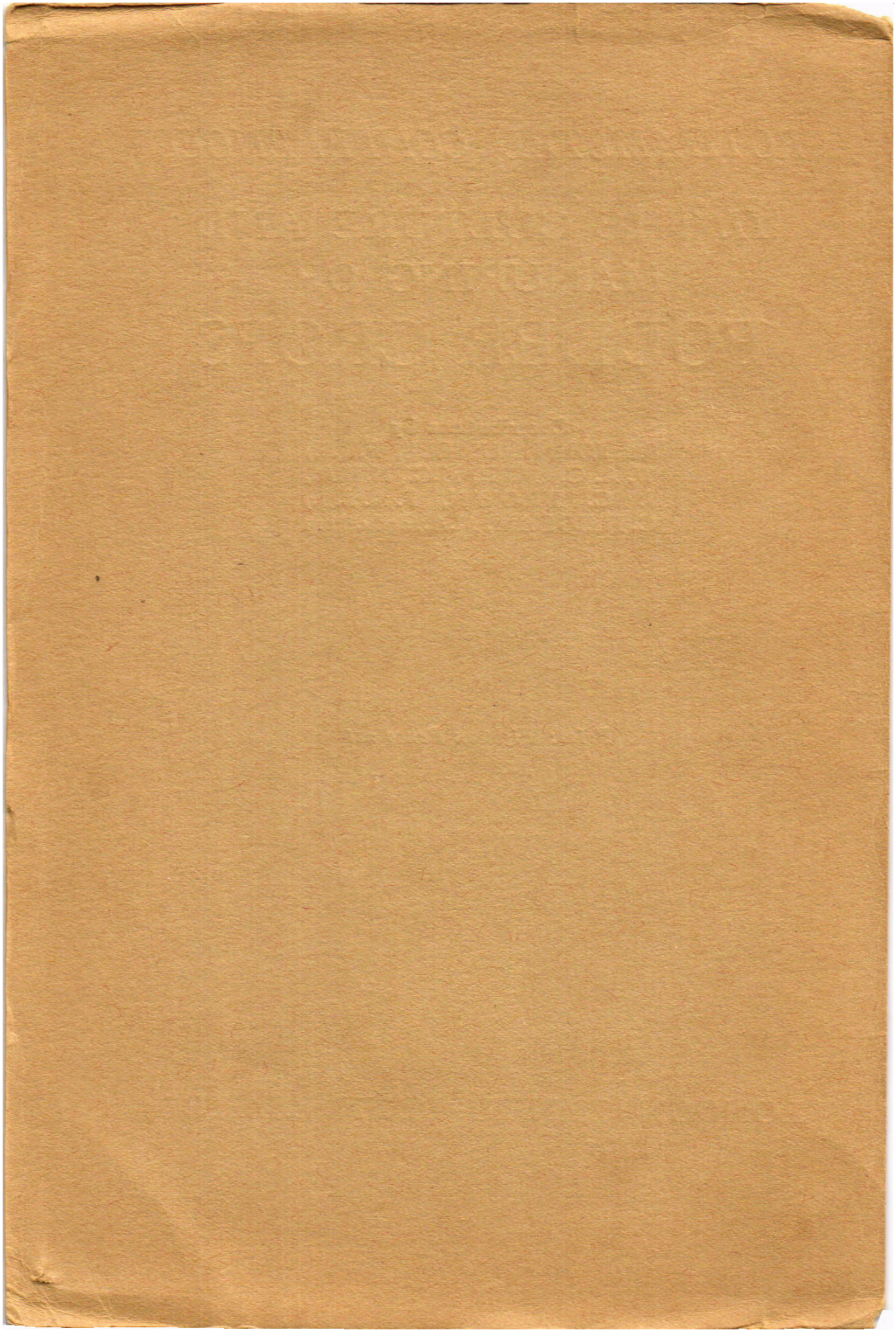

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THE CULTURE AND MANURING OF FODDER CROPS

BEING THE REPORT OF A CONFERENCE HELD AT ROTHAMSTED ON MARCH 30TH 1926 UNDER THE CHAIRMANSHIP OF

THE RIGHT HON.
LORD BLEDISLOE, K.B.E.

With Contributions by

SIR JOHN RUSSELL, F.R.S. : W. A. C. CARR, M.C., N.D.A. : J. C. BROWN, P.A.S.I. : C. HEIGHAM, M.A.
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ROTHAMSTED EXPERIMENTS ON THE MANURING OF FODDER CROPS

By Sir JOHN RUSSELL

Director of the Rothamsted Experimental Station

Fodder crops stand out in marked contrast to cereals like wheat and barley grown for direct human consumption. In the first place they are of greater value and importance to the farmer; his whole live stock—the most valuable part of his possessions—depends upon them, and he is bound to have sufficient to see the year through. Secondly, some fodder crops, especially swedes, are more dependent on climatic conditions than cereals, and they are therefore subject to greater fluctuations in yield. Thus the yields of some of our fully manured crops at Rothamsted have been:

Year	*Character of Summer*	*Yield per Acre*				
		Swedes Farm	*Mangolds* [1] *Barnfield*	*Wheat Farm*	*Barley Farm*	*Oats Farm*
		Tons	*Tons*	*Bush.*	*Bush.*	*Bush.*
1921	Dry, hot . .	Failed	31	27	34	42
1922	Wet and sunless . .	27½	12½	21	33	48
1923	Dry . .	14	37	31	36	45
1924	Late, dull, wet.	25	25	24	27	...
1925	Drought early, wet later .	Failed	27	40 [2]	48 [2]	68 [2]

Not only do the yields vary but also the response to manure. A scheme of treatment suitable for the Southern counties would be inappropriate in the cooler North or the wetter West. A third important difference from cereals is that fodder crops do not tolerate starvation conditions as for instance will wheat. Swedes grown on unmanured land at Rothamsted are hardly recognisable, being little larger than radishes, and yielding a few hundredweights per acre only; while wheat without manure on equally poor land gives a good plant quite normal in appearance and differing from ordinary crops only in its poorer tillering; the yield is only one-third that of England and Wales.

So far as manuring is concerned, fodder crops fall into two

[1] Plot 2N receiving dung and complete artificials, including nitrate soda.

[2] The 1925 yields of cereals are not directly comparable with those of earlier years, as they received rather more nitrogenous fertilisers.

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classes according as they can or cannot be grown profitably without farmyard manure. The first class includes swedes, turnips and fodder mixtures; the second includes mangolds, cabbage and kale.

Group I.—Swedes.—Swedes can be grown with artificials alone or with farmyard manure alone, but throughout England south of the Humber, and indeed probably south of the Tyne, there is no advantage in using both. The farmer must decide which to use, and if he is short of farmyard manure he will probably find it better to use artificials, applying the farmyard manure to something else.

Of artificial fertilisers for swedes, the most important is *Phosphate*, especially where yields are likely to be low. Striking increases in crop have been obtained on some soils by the use of superphosphate and basic slag—for example by Professor Scott Robertson in the north of Ireland, and occasionally by others in England: Mr Carr records a Cheshire instance. But if the land is in good condition, if it has received dung, or if the season be favourable to good growth, phosphates may have but little effect on yield. This is well seen in contrasting the poor year 1920 with the good ones 1922 and 1924. Our yields of swedes in tons per acre were:

	Poor Years		*Good Years*	
	1913	1920	1922	1924
No artificials	3·2	3·3	25·2	17·3
No phosphate, but only sulphate of potash and sulphate of ammonia .	6·4	9·3	28·1	19·1
Phosphate (slag, 1922, or super, 1924, in addition)	8·6	16·3	29·0	20·6

In 1920 the superphosphate (2½ cwt. per acre) increased the crop by no less than 7 tons per acre and converted the small crop of 9·3 tons into the very useful one of 16·3 tons, but in neither of the good years did even the complete manure add more than 4 tons per acre to the yield, and of this the phosphate contributed but little; the slag gave an extra ton per acre, and 3½ cwt. superphosphate increased the yield only by 30 cwt. per acre—not a very profitable proposition. But on the other hand the results of 1913 show that superphosphate does not act equally well in all bad seasons: in 1920 the badness had been due to cold, sunless weather; in 1913 it was due to drought, and against drought neither superphosphate nor any other fertiliser avails much. If we could predict the season we should recommend dressings of superphosphate for a cold, poor-growing season and little or no manuring for a good season or a year of drought. But prediction is not possible, and the question arises whether the farmer had better prepare for the worst or hope for the best. One year in four does not seem much

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for a striking result, especially when in the intervening years he gets only one or two tons of swedes for his dressing of superphosphate. But his live stock is at stake; and as he would be hopelessly caught out if he were without keep in a bad season, it is wisest to prepare always for years like 1920 rather than hope for seasons like 1922. A fertiliser that increases the yield in a bad season, when food is most needed, is worth a good deal to the farmer and can be forgiven if it fails to give much increase in a year of good yields, when he has already as many roots as he wants.

But there is another reason for giving phosphates to fodder crops: they bring about an improvement in quality. This is a matter of experience rather than of direct trial; the test is not easy to carry out. But there is good reason to believe that fodder crops well supplied with phosphate gain in nutritive value: the herbage of good fatting grass on Romney Marsh has been shown at Rothamsted to contain more phosphates than herbage of adjoining fields that will not fatten sheep.

Farmers generally recognise the need for giving phosphates to their swedes, but they are not always so sure what particular form of phosphate is best. Until recently there were three possibilities only: superphosphate, bones, and slag. Of these, superphosphate gives the best results at Rothamsted, and probably in most other places also. The yield of swedes in tons per acre was:

Year	*No Phosphate*	*Superphosphate*	*Basic Slag*	*Bone Meal*
1908	14·1	16·9	13·8	16·7
1913 [1]	6·4	8·6	6·6	7·4
1920	9·3	16·3	15·8	8·6

Superphosphate has also the advantage that it generally hastens the development of the young plant so that it is sooner ready for hoeing; in some seasons this is a great advantage. There are, however, instances where basic slag proved best, usually on land subject to finger-and-toe, a disease that does not trouble us at Rothamsted. As a rule the high soluble slag has proved better than the low soluble, and it does not appear that the low soluble slag is improved by finer grinding.

Fear is sometimes expressed that superphosphate may make the soil acid. This possibility has been carefully studied at Rothamsted, both on the Rothamsted and the Woburn soils, but no sign of increasing acidity has been discovered. One would not expect it, but the idea is so persistent that we should like to know how it has

[1] Many of the young plants died through want of rain; more seed was sown but failed to grow.

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arisen; and if a case were found, we should welcome an opportunity of examining it.

Recently two other kinds of phosphatic fertiliser have been offered to farmers: ground mineral phosphates and certain proprietary articles, most of which appear to be ground mineral phosphates also.

Mineral phosphates were first tested in Scotland by two well-known but widely different men: Dr Aitken at Pumpherston and Mr Jamieson in the Aberdeen district. They have remained popular in parts of the north country. Gafsa phosphate from North Africa is used in Northumberland, where the seasons are cool and moist. The essential condition is that these phosphates should be finely ground—passing the sieve with 120 meshes to the linear inch instead of the usual 100 meshes. It is said—but at Rothamsted we have no experimental evidence on the matter—that swedes grown with mineral phosphates or basic slag do not ripen so early as those grown with superphosphate, and may therefore be more useful for feeding to sheep on the land where it would be an advantage to retain the green leaves as long as possible. At Rothamsted Gafsa and Nauru were tested in 1922 and 1924, but neither year was favourable to the action of phosphate and no crop increases were obtained. The Agricultural Education Association tests with Gafsa phosphate gave promising results, and it may be worth while for the County Organiser to arrange a test of slag and mineral phosphate against superphosphate, especially if the mineral phosphate be much cheaper per unit. The test, however, cannot usually be carried out by the farmer himself; it needs proper replication or it may give very misleading results. Assistance in working out the details will always be given at Rothamsted.

Nitrogenous Manure.—Many experiments show that sulphate of ammonia applied with the seed increases the crop, 1 cwt. sulphate of ammonia giving about an extra ton of swedes per acre whether the season is good or bad:

	1922 *Good Season*		1923 *Poor Season*	
	Dung	*No Dung*	*Dung*	*No Dung*
Potash and phosphates only .	30·6	26·7	14·3	13·2
2 cwt. sulphate of ammonia in addition . . .	32·6	29·1	16·7	15·7
Gain from 2 cwt. sulphate of ammonia . . .	2·0	2·4	2·4	2·5
Gain per cwt. sulphate of ammonia . . .	1·0	1·2	1·2	1·2

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As usual, the effect of nitrogen is remarkably steady, in sharp contrast with the varying effects of phosphates; 1 cwt. sulphate of ammonia usually gives an additional 20 cwt. of swedes whether the season is good or bad. In 1924 the dressing was varied to test the effect of using larger amounts, but there was no advantage in going beyond 1½ cwt. per acre:

Sulphate of ammonia, cwt. per acre.	...	¾	1½	2¼
Yield of swedes, tons per acre .	25·7	26·1	28·2	27·4
Gain from sulphate of ammonia .	...	0·4	2·5	1·7
Gain per cwt. sulphate of ammonia, tons of swedes	...	0·5	1·7	0·8

It is not yet certain whether the nitrogen is better applied with the seed or later, but some of the experiments suggest that later application is somewhat better. It would be interesting to study the effect of time of application of nitrogenous manure on the incidence of mildew; early sowing seems to increase the liability to mildew in the South—happily Scotland does not suffer so badly—and it would be useful to know if nitrogenous manure applied with the seed had the same effect; if so, the later application would obviously be better.[1]

Potassic Manures.—Potassic fertilisers have no very marked effects on the South, but they are more useful in the North, where the growing season is longer and where, therefore, it is an advantage to keep the crop growing as long as possible.

Summing up this question of the manuring of swedes: either farmyard manure or artificials can be given, but it is not usually necessary to give both. Of the various phosphates, superphosphate is as a rule the best, but basic slag is useful on land subject to finger-and-toe, and there are indications that finely ground mineral phosphates may be useful also. But superphosphate has the great advantage of hastening early growth and so allowing of earlier hoeing, and before getting away from it careful field trials should be made; these are difficult to carry out. Nitrogenous manure gives increases of about 20 cwt. swedes for 1 cwt. sulphate of ammonia, but potassic manures are not strikingly effective. A suitable dressing of artificials is 1 cwt. sulphate of ammonia and not less than 2½ cwt. superphosphate, increasing this where experience shows it to be necessary. In southern conditions the manuring is somewhat of the nature of an insurance against bad seasons, but it will not cover drought; phosphates, however, probably improve the quality and so give better results than the figures indicate.

[1] Mr Carr informs me that in Kincardineshire top-dressings of nitrate of soda are found very useful, especially after a wet June or July.

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Mixture Crops.—Like swedes, mixtures can be grown without farmyard manure, though, like swedes, they respond quite well to it. There have been no critical experiments on the manuring of these crops, and we have only general experience as a guide. On general grounds one would recommend a dressing of basic slag and of kainit—say, 3 cwt. of each, the slag to be of high solubility.

Group II.—Fodder Crops needing Farmyard Manure—Mangolds.—Mangolds, like swedes, are greatly influenced by seasonal factors, especially rainfall and temperature—indeed they are more sensitive to temperature, and so they cannot be grown in parts of the north of England or Scotland. Rainfall affects not only the yield but the manurial scheme and the composition of the roots.

In moderately dry regions, as in the east and centre of England, the mangold requires three manures: (1) farmyard manure, (2) nitrogenous, and (3) potassic fertilisers.

(1) *Farmyard Manure.*—Dairy farmers who want large crops of mangolds and have plenty of farmyard manure sometimes give very large dressings. Surrey dairy farmers in pre-war days have been known to apply some 40 or 50 tons per acre and to get crops of 80 tons of mangolds. These heavy dressings are justified only when the farmer has so much manure he does not know what to do with it. Equally good results could be expected from, say, 20 tons farmyard to the acre and a proper dressing of artificials.

On many farms the difficulty is to find enough farmyard manure. We have experimented with two substitutes: town refuse and composts; but our tests are not yet sufficiently advanced to justify definite conclusions. The town refuse from two of the London boroughs was tested in 1923 with promising results, but many more tests are needed before useful comparisons could be made. Composts of waste straw and other like materials are being used now on our farm by Mr Heigham; from what we know of their decomposition in the soil we should expect sulphate of ammonia or nitrate of soda would need to be applied to the crop before the full benefit of the compost could be obtained.

There has been some discussion as to the best time of applying farmyard manure. This depends on the amount of winter rainfall; and if we leave out of account the question of convenience, the best results have been obtained by ploughing in the manure in autumn where the winter rainfall is fairly low, and in spring where it is high. But farmyard manure involves so much handling that the question of convenience cannot be left out of account, and probably most farmers would prefer to apply it as soon as it is available in the autumn or winter, so as to get the job done.

(2) *Artificial Manures for Mangolds.*—Of the nitrogenous manures the Barnfield results show that nitrate of soda is the best, especially

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for top-dressing, while sulphate of ammonia is most usefully applied with the seed. Nitrate of lime has, however, given good results as a top-dressing. There is little good experimental work as to the time of application, but some indication that the time of singling is perhaps the best.

(3) Of the potassic manures either 30 per cent. potash salts, kainit or muriate is suitable, but it is not certain which is the best. Both French and German kainit and the "30 per cent. salts" contain salt, and German kainit contains in addition magnesium sulphate: there is some evidence that both of these are beneficial to mangolds, and if so, kainit or 30 per cent. potash salts would be the better fertiliser. But the case is not proved, and the muriate being more concentrated involves less handling and cartage and may therefore be the more economical.

Whichever potassic fertiliser is used, it should be in some proportion to the amount of nitrogenous manure. For each hundredweight of sulphate of ammonia and nitrate of soda given to the mangolds there should be 1 cwt. muriate of potash or 2 cwt. kainit. If the nitrogen is in excess, the plant may become unhealthy and lose some of its feeding value: striking examples occur on the Barnfield plots.

The need for phosphate is less clear; it has not often been tested by experimenters, but neither at Rothamsted nor in the Agricultural Education Association tests did it produce any useful effect.

In wet districts the manurial scheme needs some modification. At Bangor, where the rainfall is very high, nitrogenous manures seem to have but little action, and in some seasons none at all. The composition of the roots also is affected: mangolds from the wet parts of North Wales contain only some 10 per cent. of dry matter; those at Aberystwyth under less rainfall contain 11 to 12 per cent. and sometimes more, while at Rothamsted and in the Eastern parts of England values up to 12 and 13 per cent. are common. Varieties differ in their composition, however, and some contain more dry matter than others; obviously, in view of the cost of handling bulky crops like mangolds, it is an advantage to grow only those rich in dry matter.

Kale and Cabbage.—Few field trials have been made with these crops, but experience shows that they respond to good dressings of dung followed by dressings of artificials, mainly nitrogenous: a mixture of, say, 1½ to 2 cwt. nitrate of soda or sulphate of ammonia, 2½ cwt. superphosphate, and 3 cwt. kainit per acre might be expected to give good results. Farmers making their own tests of manures should weigh the produce; judgment of fodder crops by eye is particularly liable to mislead.

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THE CULTIVATION & MANURING OF SWEDES & KALE

By W. A. C. CARR, M.C., N.D.A.

Cheshire School of Agriculture

Swedes belong to that unfortunate crop which is designated "roots." I say "unfortunate" because they are liable to attack, and are frequently attacked, from every quarter. Insects and fungi are ready to destroy them in the field, and even the lucky roots which escape the frost and land in the turnip shed are in danger of being thrown out again if considered a menace to the yield of the dairy cow. From time to time we are told that the crop is old-fashioned and unprofitable, yet farmers stick to it with dour determination.

We are informed we can grow silage and forage crops if we find them more profitable than hay, but roots—no! One might well ask the question—Are roots doomed? Before we cut out roots, however, we must find a substitute. Have we a crop in these islands which will yield more dry matter per acre than roots, when grown under suitable conditions? Have we found a crop which will yield digestible dry matter at a lower cost for winter feed than roots, and have we a crop the cultivation of which will keep the land clean at less cost than roots, if kale be excepted, or included under the term "roots"? So far I have not found a substitute.

Discrimination is necessary, however, in the feeding of roots as with other feeds—even linseed cake has its limits.

Swedes thrive under rather dry conditions in the early stages of growth, but the crop requires a good deal of rain after the plants begin to meet between the rows. Suitable climatic conditions are essential for a full crop. Heavy soils and wet soils seldom yield profitable crops of swedes; soils of this nature are better under grass.

The inclusion in the rotation of a good ley will do much to render root-growing profitable. Even a heavy soil becomes more friable, and tends to get into the fine condition suitable for a sound crop of roots. The ley reduces the frequency of the crop, and club root is no longer a serious menace, unless soils are actually sour. The Aberdeenshire farmer can rely on a sound crop of swedes, and he is not unduly troubled with weeds. I admit the soil and climate are suited to the crop, but the six-course rotation containing a three years' ley plays no small part. It is unfair to blame the roots for the shortcomings of other crops in the rotation, and if the land becomes weedy and out of condition through corn-growing, swedes then appear to be an expensive crop.

It may be, also, that the ley has an effect on the feeding value

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almost invariably obtained a plant, which the others sometimes missed. The root area should receive attention early in spring. The plough furrow should be broken on the surface in order to prevent the drying out of the soil. I do not care for cross-ploughing later than March, as it tends to allow the drought to penetrate to the bottom of the furrow. Better results, in my opinion, are obtained by working gradually down by successive cultivations until the desired depth of tilth is obtained. A finer tilth results and moisture rises to the plant in dry weather. Experiments at Craibstone in Aberdeenshire show the importance of sowing the crop at the right time. The soil there is of a nature which does not readily dry out, and a plant can be obtained from late sowings.

INFLUENCE OF DATE OF SOWING ON YIELD

Date of Sowing	*Average of 5 Years*		*Average of 4 Years*	
	Swedes		*Yellow Turnips*	
	Tons	*Cwt.*	*Tons*	*Cwt.*
May 8th . . .	21	9	...	
15th . . .	20	15	28	2
22nd . . .	19	4	25	8
29th . . .	19	0	23	9
June 5th . . .	17	7	23	4
12th . . .	17	8	21	6
19th . . .	...		17	5
26th . . .	...		14	0

Practical experience in the area confirms my opinion that swedes and turnips are usually sown too late for full crops.

Conditions are different in England, and it is difficult to indicate when swedes should be sown. In Cheshire the evidence is very conflicting. Swedes sown early in April sometimes make an excellent crop, whilst swedes sown in May may fail. The result may be reversed another year under different climatic conditions.

Another experiment at Craibstone shows that turnips should be thinned out when the plants are small:

	Average of 4 Years	
	Tons	*Cwt.*
Yellow turnips—		
Early-hoed .	21	16
Medium-hoed .	19	10
Late-hoed .	16	11

	Average of 2 Years	
	Tons	*Cwt.*
Swedes—		
Early-hoed .	16	14
Medium-hoed .	17	6
Late-hoed .	17	5

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of the swede. Collins has proved that the ley improves the quality of oat straw.

The preparation of the land for swedes and kale is similar. I believe in thorough cultivation, though I am afraid I cannot quote authentic experiments which show an advantage. Surely, in the preparation of land for swedes, we find an opportunity to plough a little deeper than is usual in the autumn of the year preceding the crop? Ploughing should be done early, especially if the land is at all on the heavy side. The furrow should be set up so that it will withstand the weather and be exposed as far as possible to the ameliorating influence of frost. I am often asked the question: Should farmyard manure be ploughed in during autumn or winter, or should it be applied in the drill before seeding? I do not hesitate to reply that it should be ploughed in as soon as it is available, provided the condition of the soil permits. Heavy rainfall may wash away valuable ingredients, but too often the manure is exposed to the same danger as it lies unsheltered in the farmyard or elsewhere. When the root area is considerable and the land tends to dry out, the advantage gained in the spring usually outweighs the disadvantage of manurial loss. It is not advisable to plough dung in too deep. Where conditions permit, good results may be obtained by ploughing in the manure with a light furrow in the autumn, and following later with a deep furrow. The process may be reversed on dry land. One can plough a good furrow, harrow, cart and spread the manure, and then plough in with a light furrow. By adopting these methods the manure is sandwiched between the furrows in a way which should yield good crops. The difficulty, however, is the extra expense entailed by twice ploughing, and it is probable that the increase in crop will not always pay for the extra work.

Too much time must not be spent on intensive cultivation if it is likely to cause the work to lag behind. My experience in the North-east of Scotland and in Cheshire convinces me that the failure of a swede crop could often be prevented by having the spring work a little better in hand. Unfortunately we have to contend with a variable climate, and "the best laid schemes o' mice an' men gang aft a-gley." We must, however, allow a large margin for safety, as I feel sure it is a very important factor in the cultivation of the crop, especially in places where heavy soils dry out rapidly. Every other year, if not every year, one may see whole fields sown with swedes and turnips bare and brown in July. "Yes, if we had been only a few days earlier it would have been all right." How often have I heard this, and repeated it myself. I have observed a farmer with slipshod methods push ahead with the crop when more careful men stood aside to await better weather or perform another cultivation. The former often won, as he

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Although swedes do not show an increase in yield, hoeing can be done at a greater pace and weeds can be dealt with effectively in the early stages, whereas if hoeing is delayed, the work becomes very slow and cleaning is much more difficult. The same thing applies to horse-hoeing—do the work if possible before the weeds appear.

Experiments indicate that varieties of swedes vary in yield and composition, and it is difficult to single out outstanding varieties.

VARIETY TRIALS AT REASEHEATH, CHESHIRE

Variety	1923		1924	
	Yield (Tons)	*Per cent. Dry Matter*	*Yield (Tons)*	*Per cent. Dry Matter*
Magnificent . . .	31·5	9·0	37·4	10·6
Superlative . . .	29·0	8·2	33·9	10·9
Viking . . .	29·0	9·3	35·2	10·6
Feedwell . . .	28·5	9·2	31·3	10·9
Best of All . . .	27·5	9·5	...	...
Leighton's 16-week .	27·0	9·1	...	...
Model	26·5	10·0	...	...
Conqueror . . .	26·5	9·2	33·0	11·3
Lord Derby . . .	25·0	9·8	...	...
Eclipse . . .	23·5	9·9	38·2	10·5

TYPES OF SWEDES TO TEST FEEDING QUALITY—1923

Joint Experiment, Aberdeen, Edinburgh and Glasgow Colleges, and Rowett Institute

Variety	*Type*	*Aberdeen*		*Edinburgh*		*Glasgow*	
		Weight per acre Tons	*Total Solids* Per cent.	*Weight per acre* Tons	*Total Solids* Per cent.	*Weight per acre* Tons	*Total Solids* Per cent.
Aberdeenshire Prize	Purple North	14·6	15·4	26·2	11·2	...	10·2
Bangholm	Purple Globe	14·4	14·6	22·8	11·3	...	10·3
Best of All	Reddish Globe	16·0	14·3	32·4	10·9	...	10·1
Bronze Tankard	Bronze Tankard	17·2	12·6	23·4	9·9	...	9·5
Caledonian	Br. Globe	17·4	14·2	20·0	10·2	...	9·8
Darlington	Br. Green Globe	17·9	13·8	23·8	10·2	...	10·4
Kinaldie	Green Globe	14·2	16·8	20·0	10·9	...	10·3
Picton	Red P. Tankard	18·3	12·4	29·6	10·2	...	9·6
Stirling Castle	Purple Tankard	16·0	14·0	21·3	10·6	...	10·2
X L All	Bronze Globe	15·6	13·4	23·5	10·5	...	9·9

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Manuring of Swedes.—In the past it has been the custom in many districts to apply dung and a heavy dressing of artificials to swedes. It is doubtful if this is justifiable even in Scotland. The crop does not respond like mangolds and kale to manuring, and seems more influenced by season than manuring. We have been led to understand that swedes require a liberal dressing of phosphate, yet some trials give negative results.

Results of Trials at Reaseheath, 1922 and 1923. — All plots received dung in the drill in addition to sulphate of ammonia and muriate of potash. Phosphates equivalent to 3 cwt. superphosphate (35 per cent.) per acre was applied to all plots, except the "no phosphate" plot.

The following table gives the results expressed in tons per acre :—

	Yield	
	1922	1923
Phosphatic manure—		
No phosphate	13·1	26·3
Mineral phosphate . . .	12·0	27·4
Superphosphate . . .	11·3	27·4
Ephos	12·2	27·4

Effect of Season.—Swedes have been grown at Reaseheath under similar conditions each season, and the average yield in four successive seasons is as follows :—

1921—Crop failed owing to mildew.
1922—12 tons per acre.
1923—27 tons per acre.
1924—36 tons per acre.

Provided phosphates are applied to other crops in the rotation, it is unlikely that the swede crop will suffer, when once established, through a deficiency of phosphate. With a moderate dressing of dung, a light complete dressing of artificials containing soluble phosphate is advisable. This will give the plant a good start, which I think is important. If the crop tends to be restricted in growth by heavy rainfall in the early stages, a touch up with nitrate after singling may improve the yield.

When poor land is ploughed up, phosphate may prove the limiting factor, and soluble phosphate may be necessary. A small experiment on a farm lying in the smoky area of Cheshire gives interesting information on this point.

A plot of poor turf was carefully dug up for the experiment. Carbonate of lime and a dressing of nitrogen and potash were applied to all plots. The following yield of swedes was obtained :—

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No phosphate	1·4 tons per acre
Mineral phosphate . . .	2·9 ,, ,,
Superphosphate . . .	9·3 ,, ,,

My experience in Kincardineshire also favours the use of superphosphate—small dressings bring the plants on to the hoeing stage, whereas heavier dressings of insoluble phosphate often fail to give the plant the necessary start. Superphosphate may tend to favour club root, but an application of lime now and again will counteract this tendency.

Marrow-stem kale is more reliable than swedes at Reaseheath. Crops yield from 25 to 30 tons per acre—and so far have never failed. The yield of dry matter and protein is higher than that of swedes. Cattle eat it readily in the field or in the stall, it is the cheapest autumn feed I know, and it does clean the land. Although I have put in a good word for swedes, we have lately largely replaced the crop by kale at Reaseheath, but in the North-east of Scotland kale does not compare favourably with swedes.

The cultivation of kale is similar to that of swedes. We drill it in the same way with about the same weight of seed per acre—*i.e.* 3 to 4 lb. I am often asked: Should kale be thinned? I have tried it unthinned and at distances of from ½ ft. to 2 ft. apart, and, provided the unthinned has not been thickly sown, I have found little difference in the total yield. Cattle, however, do not take readily to very thick stems, and for this reason I prefer to roughly hoe as for swedes. The crop may be planted out after early potatoes, and for this purpose it is advisable to sow a few drills of kale alongside the potatoes so that plants are at hand when required. I have sown kale successfully in Cheshire from the end of March to the end of June. Marrow-stem sown early in April will be ready to cut, if required, by August; but sowings about the beginning of May are, I think, on the whole better for use in November and December. Thousand-head kale does not yield the same weight of crop as marrow-stem. It stands the frost better, and of course provides excellent fodder late in spring, but I generally find it gets in the way of the succeeding crop.

Kale responds to manure, especially on poor soils. A good dressing of dung is desirable, and in addition we apply 1½ to 2 cwt. sulphate of ammonia, 3 to 4 cwt. super, and 1½ to 2 cwt. muriate of potash or its equivalent. After thinning we usually apply a top-dressing of nitrate. We have not carried out a manurial trial at Reaseheath, so our manuring may be wrong, but we can rely on good crops.

In 1925 we had a small experiment at Taylor Fold, near Stalybridge, on poor soil, to test if top-dressing with nitrate after hoeing was profitable. All plots received dung and a complete dressing of

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artificials—1½ cwt. sulphate of ammonia, 3 super and 1½ muriate of potash:

	Tons per acre
Basal manure but no nitrate	16·0
,, ,, and 1 cwt. nitrate of soda . .	19·4
,, ,, and 2 ,, ,, ,, . . .	22·8

The crop being of a leafy nature responds to nitrogen, and it is possible we could have profitably increased the dressing.

Kale is now finding a place on many farms in England, and farmers seem satisfied with the crop. There is, however, a danger of over-production. The produce of 1 acre of marrow-stem kale will, I think, provide sufficient green stuff for fourteen or fifteen cows up to Christmas, after which I prefer swedes or mangolds.

FORAGE CROP MIXTURES

By J. C. BROWN, P.A.S.I.

Forage crops attracted considerable attention in this country during the eighteenth century when the ancient system of agriculture was breaking up and the system now practised was taking definite form; but the economic forces of the late eighteenth and early nineteenth centuries favoured corn production, and in consequence these crops almost disappeared from British agriculture. But it is of interest to recall that in several Continental countries—notably in districts in Germany—a forage-cropping agriculture continued steadily to develop during the last century, and has at the present time reached an advanced stage of progress. In recent years in the United States of America a very considerable live-stock industry has sprung up which rests almost entirely on arable forage crops. The crops and methods employed in these countries are not well suited to English conditions, but a considerable range of forage crops exists which can be grown successfully in this country, while others need but slight improvement to render them of great value. Examples of the latter are the flat pea (*Lathyrus sylvestris*) and Bokhara clover (*Melilotus alba et off.*); both these crops give very high yields of nutritious fodder, are easily cultivated, and are almost independent of soil conditions, but the rapidity with which the stems of the plants become woody in character and unpalatable to stock renders them practically useless in their present form. Similarly, maize and lucerne, which are so largely employed in the United States, are not adapted to general cultivation, at the present time, in this

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country. We have, however, a number of well-tried crops, which, while not so productive as some of those previously mentioned, are well suited to our soil and climatic conditions, and which make excellent fodder for farm live stock. Mixtures of rye and vetches, rye and beans, rye and peas, oats and vetches, peas and oats, peas and wheat, chicory and alsike, wheat and vetches, beans, peas and wheat, beans, peas, barley and oats, and mixtures of carrots and parsnips, can be effectively employed in the feeding of live stock. The best-known of the above mixtures is of course the mixture of rye and vetches, which, on many farms, is grown for early spring fodder. In spite of its widespread use, however, it is not entirely satisfactory, because the vetches mature much more slowly than the rye, very little of the vetches being seen at the time when the rye is ready to cut, and for this reason, except when the crop is required for feeding to sheep, a mixture of rye and beans is to be preferred. Sheep are not fond of the bean plant, and eat it much less readily than vetches. Rye has also the great drawback, like Bokhara clover, that it is only palatable in the earlier stages of growth.

On light soils a mixture of peas and rye, sown early in January, will be ready for use as soon as the autumn-sown crop of rye and vetches, and is considerably less inclined to become woody. The common practice is to take a crop of turnips or cabbage after an early crop of rye used for green fodder, but if the land is clean, and early autumn fodder is needed, a mixture of St John's Day rye, or of buckwheat and peas, may be grown instead—in favourable seasons these crops may yield very heavily. On the lighter soils a very good plan is to sow rye in wide drills in September and drill peas between the rows in January, when the two crops will mature about the same time. If this mixture is cut before the flowering of the rye it is highly nutritious. A mixture of April bearded wheat and peas sown at any time during January or February is a useful mixture crop for harvesting as a grain crop; it makes very rapid growth and is well suited to the weaker soils. If desired it may be used as a hay crop. When cut for hay the mixture should not be allowed to pass the flowering stage. The most suitable mixture for making into hay is one of oats and peas. Any variety of oat or field pea may be employed, but to obtain the best results the variety of oat known as Duns should be grown, because of its hardy nature and the very large quantity of leaf and stem which it produces. This mixture should be sown in January or February, at the rate of $2\frac{1}{2}$ bushels of oats and 1 bushel of peas per acre: later sowings will give good results, but the heaviest yields are obtained from early sowings. Very heavy yields of hay, even on inferior soils, can be obtained from this mixture.

To obtain the maximum weight from the crop it is necessary

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to delay cutting until the first pods on the peas are beginning to form; but if hay of high quality is preferred to quantity, the crop should be cut when the oats are flowering. When cut thus early the crop will, in favourable seasons, make a second growth as heavy as the first, which is particularly useful on the dairy farm for autumn green fodder. When the crop has reached full growth it is not more difficult to make than any other hay, but when cut before this stage is reached it is rather difficult to turn unless the weather be good—artificial drying would be distinctly useful in this case. If well harvested this early cut hay is little short of concentrated food in value. This mixture is one of the most useful to the stock owner, owing to the heavy yields of high quality fodder which can be obtained by its use. The mixture can be used as a seed crop by sowing the Marvellous oat in place of the Duns for early sowing and any good grain oat for later sowing; success, however, depends largely on early sowing, as an attack of frit-fly on the later-sown crop may seriously reduce its yield.

Valuable as the arable hay crops are, the experience of recent years leads to the conclusion that the best results are obtained from growing the mixture crops as grain crops and feeding them in conjunction with succulent fodder. Recent experiments tend to show that a given weight of green fodder has a greater value in the form of ensilage than of hay, but the extra cost of the ensilage is a drawback to its use. A cheaper food of equal value can be produced by combining a forage mixture harvested as grain and a succulent fodder crop. The most successful of all the mixtures available for this purpose is one composed of beans, peas, barley and oats, varied according to the nature of the soil and district. It can be grown on practically all soils, and is especially suited to the weaker wheat soils and the heavy soils which need frequent bare fallowing: good crops can also be obtained on the lighter soils by suitable manuring and cultivation. The crop gives such heavy yields that it is necessary to take precautions against lodging by including a sufficiently high proportion of beans: the ideal mixture for the growing crop is half pulse and half cereal. A seed mixture made up of beans, 2 bushels; field peas, 1½ bushel; oats, 1 bushel; barley, 1½ bushel, sown at the rate of 4 bushels per acre, on average land, will give this result. On some soils this seeding would be too heavy; on high-lying lands an increased seeding might give improved returns. If the crop is sown before mid-November 1 bushel of vetches should be substituted for the peas.

The behaviour of the various species is very different in the mixture to the pure crop, and there is no doubt that each crop could be very much improved for this particular purpose. An interesting fact in this connection is the much more luxuriant growth of the cereals when mixed with pulse as compared with the pure

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crops. The taller the beans the better they are suited to the mixture, while a rapid-growing, widely branching pea, the straw of which does not ripen, is best suited for the purpose. A wide-spreading, vigorous root system in both species is also important. The crop should form a close covering over the ground at an early stage of its growth, in order that it may check the growth of weeds; once the ground is covered it is practically impossible for anything but the strongest kinds of weeds to survive, owing to the dense close growth of the crop. If sown in the autumn, or early spring, it is rarely seriously damaged by drought or excessive wet during the following summer, if the land on which it is grown is well drained. The seed may be either drilled or sown broadcast. If sown broadcast the different species should be mixed together, sown on the raw furrows, and harrowed in by giving two strokes with the spring-tined harrow. When the seed is drilled, the mixture may be sown in the usual way or the pulse may be sown separately in one direction and the cereals at right angles to it. When this method is adopted it is a good plan to sow the pulse in wider drills than the cereals, taking out each alternate coulter for the purpose. On the lighter soils it is advisable to sow deeply. No spring cultivation is required for the autumn-sown crop. The crop may be sown at any time from September until the end of March for seed and for green fodder; in some districts it may be sown as late as June. No universal rule can be laid down as to the best time to sow, as this varies with the district; but the autumn-sown crop is nearly always more resistant to adverse weather conditions. On light soils the crop is greatly benefited, in the first year, by a generous dressing of farmyard manure, otherwise the beans may not pod well. On the heavier soils, unless the land be in very poor condition, a dressing of from 5 cwt. to 8 cwt. of basic slag is sufficient to give a full yield. Top-dressing with quick-acting, nitrogenous manures is sometimes effective, but more often they do not give any return. If used at all they should be applied early.

The ordinary binder takes up the crop quite satisfactorily, and the large rough sheaves thus formed stand well in the stook and are resistant to bad weather. The crop may be cut with the ordinary grass-mower and cured in much the same way as hay. In the majority of districts the beans ripen less rapidly than the other constituents of the crop, which should therefore be cut when the cereals are ready—the beans, if not quite ripe, will ripen out satisfactorily in the stook. Early cutting greatly enhances the value of the straw for feeding purposes. The crop is thrashed with the ordinary thrashing box and any good farm grinding mill will reduce the grain to meal. One of the advantages of the crop is that it can be grown year after year on the same land with improving yield.

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Its effect on the soil is quite different from that of a pure cereal. The cereal crop, owing to its open character, allows the land to become weedy and its root system destroys the soil textures. Long ago Tull showed that cereals can be grown continuously on the same land without any falling off in yield, providing sufficient mechanical cultivation is given. The mixed crop automatically pulverises the soil by the action of the roots of the plants: the difference in the soil condition after a forage crop is obvious to the eye and touch. The smother-effect of the mixed crop is so complete that, if the land be clean when the cropping is commenced, no weeds can establish themselves beneath it; and when conditions favour the crop, really weedy land can be cleaned through the smother-effect of the crop.

The yield of the crop when grown continuously on the same land is considerably better on the average than that of the pure cereal grown in the rotation. The grain of the mixed crop is well suited to the feeding of all kinds of farm stock, and if succulent fodder is available, the straw, if well harvested, is useful fodder. The grain is a concentrate which can be easily adjusted for any particular use. The cost of growing varies from £6 to £9 per acre according to the character of the land, and on an average the yield of grain is about 25 cwt. per acre and 35 cwt. of straw. The cost per lb. of starch equivalent produced is about ·8d. Even without putting any value on the straw the grain is a cheap concentrated food. The crop is best used with marrow-stem kale as a succulent fodder: 100 lb. of kale, 4 lb. of the grain of the mixture and 4 lb. of the straw give a composition which closely approximates that of the best pasture grass. As kale can be produced at a cost of 6d. per cwt., this mixture is a very cheap food, well suited to cattle of all kinds; I have fed as much as 125 lb. per head per day to dairy cows with good results. If a more usual method of feeding is preferred, a suitable maintenance ration is 5 lb. of marrow-stem kale, 12 lb. of the straw of the mixture and 2½ lb. of the grain. The extent to which in the States the practice of feeding off standing maize and peas is carried on suggests the possibility of developing a parallel practice in this country, using in place of maize a mixed grain crop.

The mixed crops can be taken after a cereal crop in the ordinary rotation, but the most effective method of growing them is to recast the scheme of cropping on a plan which reduces the area under pure cereals but which increases their yield per acre, eliminates the greater part of the unprofitable root crop, and provides an increased and more regular supply of food for live stock from the arable land.

The following rotations, based on a large number of experiments, secures the above aims:—

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Suggested Rotations

(1)	Beans, peas, barley, oats mixture	for grain
(2)	,, ,, ,,	
(3)	,, ,, ,,	
(4)	,, ,, ,,	green fodder or ensilage
(5)	Wheat	
(6)	Kale	
(7)	Kale and mangolds	
(8)	Oats	
(9)	Seeds	for grazing
(10)	,,	
(11)	,,	
(12)	Wheat	

Scheme of Feeding Stock from Arable Land

May	Temporary pasture
June	Permanent grass
July	Grain of mixture crop
August September October	Grass supplemented with— (*a*) Aftermath of peas and oat hay crop (*b*) Maize (*c*) Buckwheat and peas (*d*) Autumn-sown marrow-stem kale (*e*) Grain and straw of mixture crop
November December	Straw and grain of mixture crop
January February	Marrow-stem kale
March April	Mangolds Grain of mixture crop Arable hay mixture

The common system of management of live stock in this country does not secure the full output of which the animals are naturally capable, because of the falling off in nutritive value of the grass during the late summer and early autumn months. By supplementing grass pasture with forage crops produced on arable land the rate of progress of the best summer period can be maintained and the carrying capacity of pastures considerably increased. The summer feeding of ensilage is a common practice in the United States: in this country a combination of mixed corn, arable hay and kale can be produced at a lower cost, and is possibly better suited to the purpose.

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MANGOLDS AND SUGAR-BEET

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In grouping together mangolds and sugar-beet in a single short paper there is some danger that the great distinction between them may be lost to view and that their many similarities alone will be recognised. It is well therefore to state by way of preamble that whereas mangolds are for the most part produced as a winter food for stock on the farm and as a land-cleaning agent in the rotation, sugar-beet are intended primarily for human food and for direct sale, and that this consideration alone is enough to keep the agricultural treatment of the two crops on different lines. The facts that beet can be used very successfully as a fallow crop and that their by-products make excellent feed for many classes of stock add greatly to their value to the farmer who grows them, but it is the cash return which they bring which is the real cause for the recent multiplication of acres under the crop.

In 1923 the area under sugar-beet in this country was only 16,920 acres, most of which was found in one district in East Anglia. Last season the area cropped was over 58,000 acres spread over a much larger district, and the current estimates show that as much as 128,000 acres are to carry the crop in the present season (Table I., p. 32).

Factories for the extraction of sugar from the beets are appearing in all parts of the country, and, for the moment at any rate, there seems to be some hope that both grower and manufacturer may derive a fair profit from the crop which will help to discount losses in other branches of the industry. Naturally enough the rapid development of this crop has been made at the expense of other crops, and of these the mangold has been the one which was most often replaced. The general similarity of habit of the two roots has led in many cases to the easy replacement of the one by the other and to the substitution of a cash profit for what has often been regarded as an inevitable and perennial loss. This has been done with but small disturbance to the normal rotation of the farms and, in cases where beet tops and extracted pulp have been used to full advantage, without reduction to the head of stock supported on the land.

For something like one hundred and forty years the mangold has maintained a high reputation as a food for stock and as a fallow crop, and through all the agricultural vicissitudes of that period it has kept its place as a crop of first-class importance.

It is typically a south land crop and has never had any vogue in

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Scotland, and the areas under it from 1910 to 1924 have been as follows :—

Year	*Acres under Mangold*
1910	442,779
1915	413,710
1920	395,680
1924	388,184

The decrease may become greater in the next year or two, because not only is the sugar-beet area extending, but it appears that the use of ensilage and kale is increasing. Quite recently the value of mangolds and other roots as a food for some classes of stock has been seriously challenged, and it has been shown that in certain situations it is possible to manage dairy herds very successfully without recourse to a ration of roots.

This revelation is as yet too new to allow any reliable estimate to be formed as to the extent of its application, but it is reasonable to expect it to reduce the area under mangolds in places where the crop has no important secondary function as a cleaning agent.

The Critical Stage in the Growing of Mangolds

The characteristics of the mangold as a cropping plant are well marked. It is deep rooted and capable when once established of drawing its water supply from deep down in the soil, and it is a gross feeder which answers very well to generous treatment.

Springing as it does from a very small seed, it is delicate in its early life and is not capable at that stage of competing unassisted with strong and quick-growing weed species. The most critical period of its growth commences immediately after germination, while the first roots have still to make their way down to an adequate water supply, and it leads a more or less precarious existence till the immediate after-effects of the process of singling have passed away.

It is the grower's business to suit his operations to the characteristics of his crop, and bearing this in mind it would appear that there is an excellent case for deep ploughing or subsoiling in preparation for the crop. Unfortunately these operations are expensive, and most mangold growers are not in a position to spend an extra thirty shillings per acre on their crop without some very definite prospect of an adequate return.

There is very little experimental evidence in support of subsoiling as a general practice, and, save in cases where a definite pan is found which hinders the free drainage of the top soil, it may be difficult to justify the extra expense involved by the operation.

The delicacy of the plant in its earliest and most critical period of growth suggests at once that it should be sown not too deeply on a fine and firm seed bed which is moist. This requirement is

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simple enough in itself, but it is often very difficult to obtain the conditions outlined and at the same time to take advantage of the season of spring cleaning before the crop is sown.

When the root shift comes round to any field most farmers find that they have weeds to kill on it, and even when an early harvest and a dry autumn allows this work to be commenced in good time much remains to be done in the spring. It happens only too often that a thorough spring cleaning leads to a dried-out seed bed and a partial failure of mangold plant. Where farmyard manure is applied in a dry spring, either on the flat or under the ridge, this risk is enhanced. No doubt the ideal to be aimed at in preparing for mangolds, in the drier parts of the country, is to have all the deep and heavy work and the organic manuring completed by mid-February, and to confine operations after that date to mere stirrings and rollings of the surface to obtain an adequate surface tilth for the seed. It is unfortunate that the vagaries of season and the accumulation of weeds of various kinds sometimes make it difficult to keep at all close to this plan of action in those districts where it would be most effective.

The incapacity of the young mangolds to deal faithfully with vigorous competitors for light and moisture is the next characteristic which the farmer must consider. He must be prepared to bring assistance to his crop at the earliest possible moment, and for this reason alone there is much to be said for the practice of growing the crop on ridges. It is possible to get the hoes to work in a ridged crop as soon as need be without fear of destroying rows of mangolds; while on the flat, even when the cereals are sown with the roots as indicators, an appreciable time must elapse before the rows are strong enough to serve as guides to the horse-hoers.

The mangold plants require a great deal of light, space and moisture for their free development, and it is only in the very earliest stages that they can live crowded together in the rows without damage to their ultimate prospects. Early singling or at least early bunching is an operation of great importance, and delay in this operation probably shares, with faulty and deep sowing, the blame for most of the failures of the crop.

It is nearly always difficult to keep the work of hand-hoeing up to date, and it is curious that more use has not been made of the various types of horse-drawn gapping and bunching machines which are on the market. In the spring of 1923 a strike of agricultural labourers occurred in Norfolk and lasted about six weeks. One of the effects of it was to disturb the working time-tables of most farms, and a number of people found themselves faced with the prospect of being unable to get their root crops hoed and singled before they were spoiled. Under these circumstances such horse-drawn bunching machines as could be obtained locally were put

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into use and several of them did excellent work. An observation taken at the time showed that with a crop of mangolds on light land, sown in flat rows 24 in. apart, the speed of working was 4·53 acres per day. The work was regular in depth and the subsequent singling out of the bunches was rendered very easy.

Once the stage of singling has been passed and the young plants are growing on freely under improved conditions the really critical stage of the crop is passed. Regular hoeings are generally considered to be beneficial as long as the horses and implements can pass through the rows without damaging the plants.

Nitrogenous top-dressings may do much to help on the plants or to develop a quick growth of leaf in the face of such attacking pests as the mangold fly or the leaf-miner grub, but these things, though they may affect the yield materially, do not generally affect the actual existence of the plants as do the earlier operations already mentioned.

Some Points in the Culture of Sugar-Beet

Many of the points stressed in the growing of mangolds are of at least equal importance with sugar-beet, but it is to be remembered that as the use and the price per ton of the two crops vary very widely, so must the grower's regard for the points at issue be modified.

With mangolds the chief consideration is the weight of roots per acre which can be produced for the feeding of his own or someone else's stock. With sugar-beet the critical figure is found in the amount of sugar per acre which can be grown and sent to the factory.

The quality factor in the crop assumes an added importance, as it comes to have a direct cash value, and the grower is brought to consider his operations from a different point of view.

In the first place the question of subsoiling as a preparation for the crop assumes a new aspect and the arguments in favour of it become more cogent. As the return to be expected is greater so the outlay that can be afforded may be increased, and the thirty shillings per acre which seemed prohibitive with the low-priced crop appears more reasonable with the sugar-beet. Further, the nature of the sugar-beet itself lends force to the arguments in favour of it on all but the deepest and loosest soils.

The root which it is desired to grow is long and tapering and almost entirely subterranean. It is free of branches or "fangs" which, when trimmed off in the field or at the factory, lead to a loss both of weight and of sugar content. It seems certain that the free and quick growth of the deep-rooting system of a plant which requires a great deal of moisture for transpiration during its life must be encouraged by the thorough breaking of the subsoil by mechanical means.

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This supposition finds ample support in the practice of most of the more advanced sugar-growing countries, and subsoiling or deep ploughing, 12 to 13 in., has become, in many cases, a matter of routine in preparation for the crop.

The question of the time of application of the farmyard manure and its nature also has some bearing upon this point of form and quality in the root, for it has been found that late applications of dung, or the use of it in a long or ill-rotted state, may lead to that forking and branching which it is desired to avoid. For this reason, as well as in order to avoid the danger of drying out the seed bed, winter applications of dung, 12 to 13 tons per acre, are generally recommended.

Seeding

The sugar-beet seed is almost exactly like that of the mangold, and equal care in the preparation of a bed for it is required. Under ordinary conditions the ultimate yield of sugar per acre will depend more upon the number of roots grown than upon either the size of individual roots or the percentage of sugar in them. It is therefore particularly important to obtain a close and even plant over the whole area under the crop. In order to do this it has become the practice in some Continental countries to place the rows very close together and to use a very large seeding. Rows 14 in. apart and seedings up to 25 and 30 lb. per acre are found in Holland and parts of Germany. In the matter of the heavy seeding it is often argued that if 7 or 8 lb. of mangold seed per acre will give a thick plant which requires drastic singling, a great part of the 15 to 20 lb. recommended for sugar-beet must be wasted. It is certainly true that the 7 to 8 lb. seeding can, under good conditions, produce enough plants per acre for a good sugar-beet crop, but the conditions are so often not good and the importance of securing a "tight plant" is so great that the extra seed may be regarded as a measure of precaution which costs the grower some 7d. or 8d. per lb.

The use of very narrow rows is a matter which demands separate consideration, for a great deal of the subsequent cost and management of the crop must depend on the decision. The recommendation to use them comes from countries where the problem of securing good manual labour on the land is not the same as in this country. Where hand labour is plentiful and cheap it is probable that the benefit to be derived from growing the roots as close together as possible may outweigh the additional expenses of seeding, hoeing and harvesting. In England agricultural labour is neither plentiful nor cheap, and it is often practically impossible to obtain and house extra hands in rural districts.

Perhaps at some future time, when the sugar-growing industry

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is more firmly established, it will be possible to erect standing camps and barracks for the imported hoeing and harvest hands, as is done for hop and fruit gatherers in some districts, but at present there is no more than a bare indication of this development.

Under the existing conditions it seems that we cannot afford to replace horses with men, and if the narrow rows involve this change then we have very good reason for not using them. In many districts farmers are growing sugar-beet with the same operations and at the same distances as they have grown other roots for years past. This enables them to produce a new crop without extra implements and with the assurance that the men will be able to handle the operations easily. There can be no reasonable doubt but that the crop requires closer spacing than our other root crops, and a measure of this can be obtained without sacrifice of time and labour-saving machinery.

Rows 18 to 20 in. apart, with the roots 10 in. apart in the row, allow the ordinary operations of horse-hoeing to be carried through cleanly and punctually, and at the same time permit of a root population of about 34,600 per acre, which under good conditions is equivalent to a crop for sale of 12 to 13 tons per acre.

It is possible that with the very high price of beet obtained during the past year or two, and which will be continued for this year, the strict economies of cultivation may lose some of their point, but it is to be remembered that this high price is due in part to a temporary subsidy paid by the Government to the factories. In a definite time this subsidy will shrink and disappear, leaving the industry to fight its own battles in the world markets.

The present period is necessarily one in which the position and technique of both the growers and the factories must be built up and strengthened, and it is important that only those methods which are recognised as being the most efficient and most economical shall survive to the era of open competition.

Sugar-beet are generally grown on the flat, but quite a number of new growers in this country who have been used to growing other roots on the ridge, and who appreciate the advantage in cleaning which this method gives them, are inclined to challenge the established practice. There does not seem to be any very reliable experimental evidence to support either method as against the other, though it is said that to carry the maximum content of sugar the root should be as much underground as possible. If this is true, it would appear that the advantage must lie with the practice of sowing on the flat.

The actual process of drilling is a critical one, as it is very important that the seed bed should be fine and that the seed should

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not be buried too deeply. The seed rates already mentioned, 15 to 30 lb., are below those found in many Continental districts, but even so there may be some considerable difficulty in getting on the required amount of seed per acre with the drills commonly found in this country.

There are various special drills coming on to the market now that the crop is becoming an important one, but with a little modification of the size of its cups and some alteration of gearing an ordinary "flat-work" turnip drill can generally be made to do the work. A common type of sugar-beet drill used in Germany is nearly 14 ft. long, and will cover eight or nine rows at a time. Behind each seed-spout of this machine follows an iron presser-wheel which serves to push the seed down ½ to ¾ in. on to a firm bed. Great importance is attached to this firm planting, and thorough rolling of the rows immediately after sowing is generally to be recommended. The practice of sowing a little barley with the beet seed in order to get early definition of the rows is common in Germany and works well in England.

Hoeing, Rolling, Bunching and Singling

The exact sequence of operations must depend upon the soil and the season, and it may be necessary to frame the programme either to conserve moisture in the soil or to draw it up to the seeds at the surface.

In some places—for example, Silesia—great value is placed upon very early hoeing, and where there is a delay in the appearance of the beet "blind hoeing" is practised.

Whatever the wisdom of this may be, it is certain that all the best growers use their hoeing implements freely whenever opportunity offers, and continue the work until quite late in the growth of the crop.

There are various kinds of special horse-hoes for sugar-beet now coming on to the market, but good and close work can be done with the existing tools if they are fitted with suitable hoe-blades and are carefully set. The Danish type of horse-hoe, which has a disc to run beside and protect the young plants, is very well suited to the early work with sugar-beet.

Bunching, which is accomplished with a heavy hand-hoe 8 to 10 in. wide, should take place as soon as the young plants form definite and continuous rows. Care must be taken that the hoe stroke is deep enough to destroy the unwanted plants and generally it should not be less than 1½ in. The work requires care and close supervision, especially in districts where the men have not had much experience of root hoeing.

Singling, which follows the bunching, should begin as soon as the

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young plants have four leaves (Table II., p. 33). It is a very critical operation both in point of time and in the care which is required in it. The young plants in the bunches tend to twine together, and the longer they are left the more difficult becomes the task of disentangling them. Singling cannot be done really well with the hoe alone, it requires the fingers and meticulous care. The best plant of each bunch should be selected and held down firmly in the ground with one hand while the remaining plants are removed with the other.

When singling has been really well done the plants should be left evenly spaced in the rows (8 to 10 in. apart) and so well planted that the shock of the drastic operation through which they have passed is reduced to a minimum.

Singling may be followed immediately by rolling to restore the firmness of the top soil round the plants, and the hoes should be busy again without unnecessary delay. Hoeing, both with drawn hoes and with hand tools, is continued until the leaves of the crop form complete land cover, and some damage to the crop is sometimes excused on the ground that the benefits arising from the hoeing will more than make up for it.

Manuring of Sugar-Beet

Although a great deal of research work has been done on the Continent in ascertaining the manurial requirements of the sugar-beet, there is practically no experimental evidence which has a direct bearing in this country. There is work in hand at the present time at Woburn which is designed to tell us something of the action of nitrogen and potash upon yield and sugar content. Somewhat similar work has been carried out by the Norfolk Agricultural Station in the past two years, and there is a scheme in being for a co-ordination of plans of experiment in several counties.

The results so far obtained require confirmation before they can be considered as being really reliable, but in the main they agree with the recommendations made to growers in Germany.

Further investigation is required into the relative values of farmyard and green manure for sugar-beet, and there is much to be done in following up the action of potash in the plant and its influence upon the gross yield and the sugar percentage. From the work already done it appears that sulphate of ammonia and nitrate of soda in quantities above 3 cwt. per acre may cause a small reduction in the percentage of sugar in the individual roots, but this tends to be outweighed by the increase in yield of roots and in the sugar per acre.

A great many English growers give their sugar-beet the same dressings as their mangolds or potatoes, and successful crops have

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been produced in this way. Both mangolds and potatoes are potash-loving plants and answer well to large doses of the various potash salts, but it is by no means certain that the sugar-beet is equally responsive to heavy potash dressings.

Sugar-Beet as a Forage Crop (Table III)

The forage value of sugar-beet is found in the by-products. These are the tops, the extracted pulp and the beet molasses.

The tops consist not only of the leaves but also of the upper part of the root down to the lowest leaf bud. They weigh from 5 to 10 tons per acre and form a very valuable feeding stuff available for nearly all classes of stock. They are sometimes fed fresh in the field but are more often made into silage in large pits.

The pulp straight from the factory is a valuable cattle food, and is used extensively all over Europe for both fattening and milking stock. Unfortunately it is heavy and bulky to handle, and is not easily conveyed from the factory to the more distant farms. In this country all the factories have drying plants, and the pulp is dried out before it is sold back to the growers or is put on the general market.

Under many contracts the grower has the option on a weight of dried pulp equal to 5 per cent. of his root deliveries. The price to growers at the present time is about £5 per ton.

A comparison between the ordinary root crops—swedes and mangolds—and "dried sugar-beet slices" was made at the Norfolk Agricultural Station in the years 1909 and 1910. Two yards of fattening bullocks were fed on identical rations with the exception that one lot received the ordinary ration of roots and the other a calculated quantity of dried slices which had been soaked in water the night before. The results obtained were remarkably consistent and showed that for the purpose in question 14 lb. of dried pulp were equal to 1 cwt. of mangolds.

TABLE I

SUGAR-BEET AREAS IN ENGLAND

Year	*Acres*
1920	3,017
1921	8,333
1922	8,400
1923	16,920
1924	22,440
1925	58,700
1926	128,000 (estimate)

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TABLE II

A GERMAN EXPERIMENT

Time of Singling	*Yield in Tons*
At the proper time	15·0
One week later	13·5
Two weeks later	10·0
Three weeks later	7·0

TABLE III

SUGAR-BEET BY-PRODUCTS

Constitution

	Sugar-Beet Tops	*Sugar-Beet Pulp*	*Mangolds*	*Swedes*
Crude protein	17·41	10·43	8·35	10·01
Oil	2·32	0·70	0·85	1·54
Fibre	8·27	20·01	5·84	9·24
Carbohydrate	51·37	64·86	79·12	73·82
Ash	18·03	4·00	5·84	5·39
Earth	2·10	...	...	...
Moisture	83·9	84·8	89·3	88·5

THE DISCUSSION

Lord Bledisloe, Chairman of the Conference, speaking in discussion, said that with reference to the matter of the early sowing of swedes mentioned by Mr Carr, his own recent experience showed that swedes sown very early in Gloucestershire suffered badly from mildew.

In the matter of varieties he was interested to observe that the Danish swede, Bangholm, had done so well both in total yield and in yield of dry matter in the trials at Aberdeen, Edinburgh and Glasgow.

Concerning marrow-stem kale he had found that it is an excellent food for pigs, and he considered that for this class of stock it is second only to lucerne. His own kale crop had stood the severe frosts of last winter without damage.

Mr Crawford was anxious to know how the dressings of artificials which had been put forward compared with dung when measured

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in the later crops. He had some fear that continued heavy dressings of artificials might lead to the occurrence of such troubles as acidity in the soil, which would more than counteract the good done by the manures themselves.

Mr HUNTER SMITH said that he had some curiosity as to how the yields mentioned in Mr Carr's paper had been measured. During the last year he had been examining the matter of the measurement of yields of root crops at the Oaklands Institute of the Hertfordshire County Council. An area of marrow-stem kale carrying what appeared to be a good crop was submitted to the inspection of farmers and land valuers.

The farmers estimated the yield as anything up to 40 tons per acre and the valuers placed it very much higher. One acre of the crop was harvested in eighty equal plots, each of which was carefully weighed. The weighings showed that the yields varied between 9 and 28 tons per acre, with an average of 21 tons and a probable error of 3 per cent. A similar experiment was made with some mangolds, which yielded on the average 20 tons to the acre, with a probable error of 2½ per cent. In this case the visiting farmers' estimate was 30 tons to the acre.

It was obvious from the great error of the estimates and from the wide spread between the extremes on the kale plots that any single measurement of the yields would be misleading. Using the kale and mangold crops in feeding experiments at Oaklands it had been found that weight per weight they varied in feeding value as 10 : 13 in favour of the marrow-stem kale.

Mr J. PORTER said that his own experience with a three years' ley agreed with that of Mr Carr, and that he had found it excellent for cleaning the land, for supplementing dung, and for improving the mechanical condition of the soil.

Concerning the choice of phosphatic manures for swedes, he had found that superphosphate tends to bring the crop earlier to the hoe than do mineral phosphates, and therefore helps forward maturity and makes it easier to get the land clear in time to plant corn. Where it is desired to fold sheep on the roots there is much to be said for the use of basic slag, which, in his opinion, tends to keep the tops green for a longer period. He thought that a mixture of slag and superphosphate is generally more effective than either one or other by itself. On sour light land on Herefordshire slag has been found to be superior to superphosphate both as regards the total yield of the crop and the quality of the roots.

Mr S. F. ARMSTRONG observed that in some parts of the Eastern counties the early cutting out of swedes is considered to be danger-

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ous on account of damage that may be done by turnip-fly when the young plants are thinned out and temporarily checked in growth.

With regard to the use of artificials, he thought that a good deal must depend upon the time of application, and he was anxious to hear of the results of any experiments bearing on this point.

Mr W. A. Carr in reply to Lord Bledisloe said (*a*) that in his experience in the North-east of Scotland and Cheshire dung was always put to swedes because it was available and was most easily disposed of in this manner. Of course the crop can be grown successfully without dung where supplies of it are difficult to obtain. (*b*) That the smoky atmosphere in the industrial districts round Manchester is actively harmful to the soil, which tends to become strongly acid under its influence.

In reply to Mr Crawford he said that in North-east Scotland most of the soil is notably deficient in lime, and practically no extra lime is added by the farmers. Despite this, very large doses of superphosphate and sulphate of ammonia are used there from year to year without the occurrence of any harmful results due to acidity or bad soil texture. Good clovers of both the red and wild white types are grown on land treated in this way.

In the matter of early singling he maintained his position, but agreed with Mr Armstrong that there is strong counter-opinion founded on the fact that the turnip-fly sometimes destroys a large proportion of the young plants and that late singling gives the farmer a greater number of survivors to choose from when the rough leaf stage is thoroughly established and the fly danger overpast.

Mr Bond said that in regard to the future of sugar-beet growing he feared there is some ground for apprehension. He understood that there is something like 1,000,000 tons of sugar at present lying in the docks and that it can be bought wholesale at very low rates. A Ministry of Agriculture publication has shown that the average cost of growing sugar-beet recently on some six hundred acres of land on many different farms was something like £23 per acre. Such great outlay can only be justified if a high price per ton for beet can be maintained.

He agreed with Mr Heigham in that there is practically no experimental evidence in support of the practice of subsoiling, but he had yet to be convinced that late horse-hoeing is not calculated to do more harm than good to the root plants.

His own experience confirmed the recommendation of a really firm seed bed for mangolds, and he had found that it is generally easier to obtain this on the ridge than on the flat.

Referring to the whole subject of home-grown fodder crops, he quoted a case where a crop of marrow-stem kale had obviated the

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purchase of other feeding stuffs to eke out the late summer grass. Further, he had found that on a farm on which costing accounts were kept under the Derbyshire County Council scheme it had been possible to produce home-grown food at just half the price of the equivalent in purchased concentrates.

Mr STEWART considered that the system outlined in Mr Brown's paper is too expensive, too complex, and is unnecessary. With the aid of marrow-stem kale, mangolds and lucerne, a skilled farmer can make the most of his grass without recourse to a soiling system. The mixed straw of the ripened fodder crops is very coarse and hard, and its feeding value is therefore low. Mixed forage is extremely difficult to make into hay even in a good season, and the fully ripened crops are far more difficult to win than any pure cereal crop. He considered that it is generally more profitable to grow an ordinary corn crop for sale in the market.

Mr CARR had found that mixed fodder crops are of little use in Cheshire, as they nearly always go down long before they reach the green yield of 20 tons per acre claimed by Mr Brown. He found that for hay he can get better results with Italian rye-grass than with mixtures of peas and oats. He had not been very successful in obtaining the smother-effect with the mixed crops. After growing them for four successive years on the same light land the weeds were still strongly in evidence. This same piece of land was put down to grass along with another bit which had carried roots, and the grass seeding did better on the latter.

He was able to confirm Mr Brown's claim that the cereals in a mixed crop appear to be more vigorous than when grown alone. He thought that on the average they may be 6 in. higher, but unfortunately he had not been able to compare any grain yields of plants under the two conditions.

Mr EDEN said that on an East Anglian farm which was included in the Ministry's scheme for the costing of sugar-beet he had observed that where dung was used a cash loss had been made upon the crop. This fact appeared to have serious bearing upon the question of the economic manuring of the sugar-beet crop, and he was anxious to know if a similar state of things is found on many other farms.

Mr HEIGHAM replying to Mr Porter said that he had encountered the practice of soaking sugar-beet seed in water before sowing, both on the Continent and in this country. He could not say definitely that it is always advantageous, as in the event of very dry conditions following upon the quick germination of the wetted seed there is likely to be a heavy mortality among the young plants.

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Concerning the use of wheeled hoes in order to economise hand labour, he knew the Planet Junior type and had it in use on the Rothamsted farm, but he had not used it as yet on a sugar-beet crop.

Answering Mr Eden, he said that the loss on a crop following the use of farmyard manure generally depends very much on the cost of making the manure. This is a very complicated question in itself which cannot be dealt with extempore. Sugar-beet, like many other crops, can be grown quite well on land in good heart without the use of dung, but any system of arable farming without organic manure is not calculated to produce good results over a period of years.

Mr Brown in reply to his various critics said that the whole reason for such a system of cropping as he had outlined is that ordinary four-course farming with its high proportion of expensively grown cereal crops does not pay under modern conditions. Corn taken after a three years' ley or two years of smother crop is far more cheaply produced per bushel and can be grown at a profit. Mixed corn is nearly always more productive than a pure cereal crop and reckoned as starch equivalent; it makes a very cheap food for most classes of stock.

It is true that mixed crops take long to dry in the field, but they are very resistant to bad conditions and can survive weathering which will ruin pure crops. Pea and oat hay if cut early and at its best is certainly difficult to make, but it is valuable enough to be worth some trouble.

He agreed with Mr Carr that in the wetter districts, and where forage crops tend to lodge early in their growth, Italian rye-grass may produce exceptionally good results.

Answering Mr Fishwick, he said that in order to obtain forage crops in August and September when the grass is failing, marrow-stem kale can be sown early in the spring and top-dressed with nitrogen. In order to ensure for it an even better start the crop can be sown in a seed bed in autumn and planted out in the spring. In dealing with autumn-sown kale considerable care is necessary in the selection of the strains, as these may differ widely in their liability to bolt and their winter hardiness.

With regard to the effect of smother crops in overcoming "twitch," he said in reply to Mr Porter that at Harper Adams College almost perfect smothering was obtained, but that it is not always so good in other places and in all seasons. He suggested that deep ploughing followed by a quick seeding of a smother crop is, on most soils, a good method of dealing with the weed. He maintained strongly that, sown on a clean field, a succession of mixed smother crops will serve to keep the land clean.

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SUMMARY OF POINTS

By C. HEIGHAM, M.A., and H. V. GARNER, M.A., B.Sc.
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(1) *Crops for Stock Feeding.*—The present trend of English farming favours the development of stock husbandry of various kinds, and the traditional crops of cereals for direct sale are therefore declining in economic importance.

(2) In arranging systems of cropping for the feeding of live stock it is important that the probable yield of dry matter per acre be kept in view.

(3) Crops of swedes, mangolds, marrow-stem kale, various forms of arable hay and mixed fodder crops of pulses and cereals may all yield considerably more dry matter per acre than do the standard cereals.

(4) Home-grown feeding stuffs can be produced at a price per pound of starch equivalent which is well below that paid for purchased materials.

(5) By the use of well-made arable hay, some roots and kale, and meal from the grain of heavy-yielding mixed crops of pulses and cereals, the farm bill for concentrated foods may be greatly reduced without a corresponding fall in output.

(6) The by-products of the sugar-beet in the forms of tops and extracted pulp give many tons per acre of valuable stock food which, if well used, may greatly increase the value of the crop on the farm.

(7) The area under the older crops, such as mangolds and swedes, tends to decrease as kale and ensilage crops gain in popularity and as they are replaced with sugar-beet, which has both a cash and a fallow value. Recently it has been found possible to conduct some types of dairy farming very successfully without heavy rations of roots, but it is not yet clear how far this practice may develop, particularly in those arable districts where the secondary or cleaning function of the root crop is of great importance.

(8) Fodder crops are generally less reliable in yield than are cereals, and complete failures are not uncommon. Such failures may be extremely serious, as the supply of food for the stock of the farm depends upon these crops. Prudence suggests that an ample acreage of the fodder crops be grown in each year as an insurance against a bad season, though in a bountiful one this policy may lead to what appears to be some waste of crop.

(9) *Manuring of Fodder Crops.*—Swedes, turnips and mixture crops may be grown successfully without farmyard manure and with artificials, or with farmyard manure and without artificials. In

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England it is generally not worth while to use both together with these crops.

(10) Mangolds and kale require farmyard manure as well as artificials if the best returns are to be obtained. In the absence of adequate supplies of farmyard manure some encouraging results have been obtained with town refuse and with composts made from waste straw, cavings and other organic rubbish.

(11) *Phosphatic Fertilisers.*—Swedes and turnips generally respond particularly well to dressings of phosphates, and of the phosphatic manures in common use superphosphate is generally the most effective for these crops.

(12) Basic slag has some advantage over superphosphate on land where "finger-and-toe" is known to be prevalent. In using basic slag it is well to remember that the high soluble slags generally produce better results than the low soluble ones, even when the latter are very finely ground.

(13) There is no experimental evidence either at Rothamsted or Woburn to show that superphosphate makes the soil acid.

(14) Mineral phosphates finely ground have given good results in Scotland and the North of England where the seasons are cold and moist.

(15) *Nitrogenous Fertilisers.* — Adequate supplies of nitrogen are required by the succulent fodder crops, and applications of the ordinary nitrogenous manure salts give more consistent results than do other fertilisers. In most seasons an application of 1 cwt. per acre of sulphate of ammonia will give an increase of 1 ton per acre of swedes.

(16) Sulphate of ammonia with the seed and top-dressings of nitrate of soda or nitrate of lime give satisfactory increases with the mangold and kale crops.

(17) There is very little experimental evidence to show the best time for applying top-dressings to root crops, but practical experience suggests that this may be directly after singling.

(18) *Potassic Fertilisers.*—Applications of potash produce particularly good results with mangolds. Thirty per cent. potash salts, kainit and muriate of potash have all been used with good effect, and it is uncertain which of them is the best. The two former contain common salt, which is said to be very effective on root crops in some districts.

(19) Potassic fertilisers should be used in balance with nitrogenous manures. With each hundredweight of sulphate of ammonia or nitrate of soda given to the mangolds 2 cwt. of kainit or 1 cwt. of muriate of potash should be applied. Without this balance the plant is likely to be unhealthy and may lose some of its feeding value.

(20) *Cultivation of Fodder Crops.*—With all the root crops the

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production of a seed bed which is at once fine, firm and moist is of the utmost importance. Free use of the roller both before and after seeding is to be recommended.

(21) There is little good evidence of profitable increases of crop obtained through subsoiling except in cases where a definite and impermeable "pan" has been broken up. The case of the sugar-beet crop deserves special consideration, as both the yield and quality of the roots depend to an unusual degree upon easy penetration of the soil to a considerable depth.

(22) Loss of moisture in the top soil when preparing a seed bed is a common cause for failure of plant in root crops. This may be avoided to some extent by ensuring that all the deeper working is done in the autumn and winter.

(23) Great importance is attached to the time of singling root crops. Sugar-beet and mangolds should be singled as soon as the young plants show four good leaves. With swedes, singling should begin as soon as the development of the "rough leaf" is sufficient to ensure that the full risk of attack by turnip-fly is past.

(24) The hoeing of roots should begin before the weeds appear, when it can be carried through quickly and easily. If this is done the danger arising from the competition of strong growing weed species in the weak and early stages of the crop will disappear.

(25) The growing of roots on the ridge facilitates early hoeing and is said to make easier the desired compacting of the seed bed.

(26) Early seeding has often been found to be one of the main factors of success with swedes, turnips and mangolds. Delays at sowing time, even when they allow extra cultivations to be carried through before drilling, may prevent the establishment of a strong and even plant, and so have a very serious effect upon the ultimate yield of the crop.

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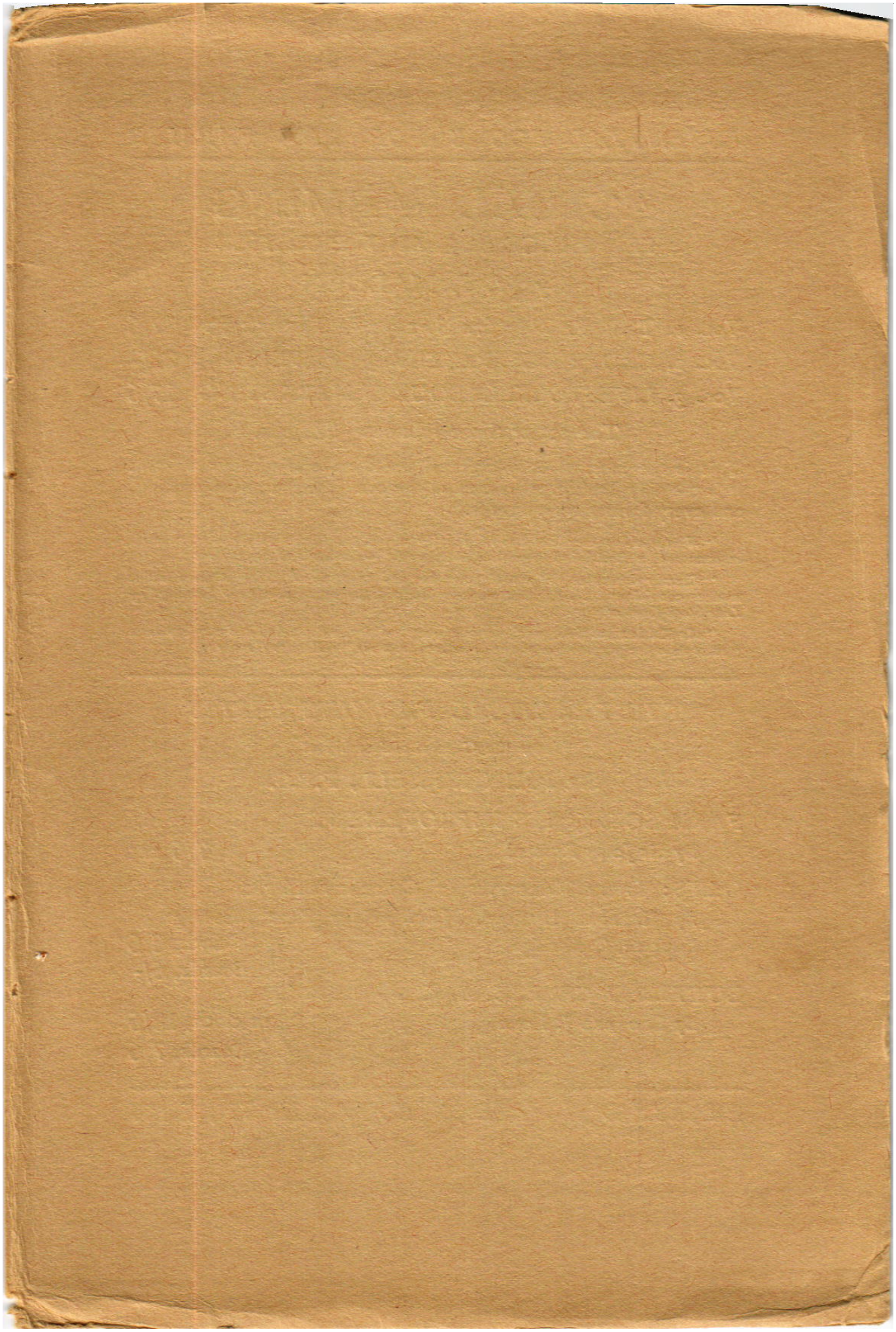

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