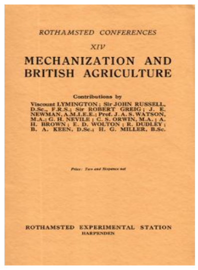
ROTHAMSTED RESEARCH

Mechanization and British Agriculture

Full Table of Content



XIV. Mechanization and British Agriculture

The Earl of Radnor

The Earl of Radnor (1933) *XIV. Mechanization and British Agriculture ;* Mechanization And British Agriculture, pp 1 - 58 **- DOI: https://doi.org/10.23637/ERADOC-1-207**

ROTHAMSTED CONFERENCES

XIV

MECHANIZATION AND BRITISH AGRICULTURE

A

ROTHAMSTED CONFERENCES

THE booklets in this series contain the papers and discussions at the conferences held from time to time at Rothamsted on present-day problems in crop production. The papers are written by well-known experts and discussed by some of the best practical farmers.

Obtainable from the Secretary, Rothamsted Experimental Station, Harpenden, Herts.

"THE MANURING OF POTATOES." 1/6.

(1)* "THE GROWING OF LUCERNE." 1/6.

(2) "THE CULTURE AND MANURING OF FODDER CROPS." 1/6.

(3) "GREEN MANURING: ITS POSSIBILITIES AND LIMITATIONS IN PRACTICE." 2/-.

(4) "THE CULTURE AND MANURING OF SUGAR BEET." 2/6.

(5) "ART AND SCIENCE OF CULTIVATION." 2/-.

(6) "POWER FOR CULTIVATION AND HAULAGE ON THE FARM." 2/6.

(7) "MALTING BARLEY." 2/6.

(8) "RECENT CHANGES IN SYSTEMS OF HUSBANDRY IN ENGLAND." 2/6.

(9) "THE HERTFORDSHIRE AGRICULTURAL SITUATION: CAN IT BE IMPROVED?" 2/-.

(10) "THE GROWTH OF CHEAPER WINTER FOOD FOR LIVE STOCK." 2/6.

(11) "THE MAKING OF NEW GRASSLAND: EXPERIENCES OF PRACTICAL FARMERS." 2/6.

(12) "THE PLACE AND MANAGEMENT OF SHEEP IN MODERN FARMING." 1/6.

(13) "THE TECHNIQUE OF FIELD EXPERIMENTS." 1/6.

Numbers 1 to 10 inclusive are also published in book form:
Vol. I (1-5), Vol. II (6-10), 10/- each, postage extra.

* Out of print in separate copies.

MECHANIZATION AND BRITISH AGRICULTURE

BEING THE REPORT OF A CONFERENCE HELD AT ROTHAMSTED ON FEBRUARY 9TH 1932 UNDER THE CHAIRMANSHIP OF

The Right Hon. THE EARL OF RADNOR

With Contributions by

VISCOUNT LYMINGTON; SIR JOHN RUSSELL, D.Sc., F.R.S.; SIR ROBERT GREIG; J. E. NEWMAN, A.M.I.E.E.; PROF. J. A. S. WATSON, M.A.; G. H. NEVILE; C. S. ORWIN, M.A.; A. H. BROWN; E. D. WOLTON; R. DUDLEY; B. A. KEEN, D.Sc.; H. G. MILLER, B.Sc.

ROTHAMSTED EXPERIMENTAL STATION
HARPENDEN

CONTENTS

FOREWORD

BY SIR E. J. RUSSELL

THREE great appliances have in the last ninety years been given by science to crop production: the first was the artificial fertiliser introduced in 1843; the second, some sixty years later, was the new way of producing new varieties of plants; and the third is the internal combustion engine now becoming increasingly prominent in agricultural developments. This was not the first engine to come on to the farm: it had already been preceded by the steam engine. But there was this important difference in the circumstances of their introduction and development. The steam engine was used in the 1860's to do a new job: to plough more deeply in the hope of getting the bigger crops which at that time were the ambition of good farmers. Afterwards, when the bad times of the 1890's set in, the big crops were no longer profitable and the steam engine ceased to play the part that its friends had expected. The internal combustion engine, on the other hand, was introduced to save labour, and the urgent and continuing need for this is shown by the fact that wage rates on all farms are now nearly 100 per cent. above pre-war level, and show no tendency to fall, while prices of farm produce are on the average only about 40 per cent. above, and for many farmers they are almost down to pre-war level. There is only one way of meeting the disparity and that is to furnish the worker with a machine so that one man may do the work of two.

The Rothamsted Conference dealt only with the technical problems involved in this arming of the farm workers with machinery. It can be done in two ways. The farm system may be radically changed and based on machinery instead of hand labour as at present; to be effective the change must be logical, complete and ruthless: machines have no sentiment. If this were done with adequate thoroughness, cereal farming could be made profitable over large areas of the south and east of England even in open competition with the rest of the world—provided only that the competitors were not helped by subsidies or unpaid labour. But it would mean heavy reductions in numbers of men now employed on the land; and their most probable fate would be to migrate to the towns and cities where provision exists for mass-relief. Alternatively, the system can remain substantially as at present and the machine introduced to lighten the day's labour and to increase

https://doi.org/10.23637/ERADOC-1-207

the amount of work that can be done in a spell of fine weather. This is the obvious use for machinery on a live stock farm, where human labour must remain the foundation of all the work.

There is no question that British farmers as a whole would prefer the second alternative ; they like the machine as a servant but not as a master, and they intensely dislike discharging men whose only fault is that, for some reason which neither party quite understands, they have become unwanted. Empty cottages and depopulated villages are probably more distasteful to farmers than to any other section of the community.

Both methods are dispassionately discussed in the succeeding pages. Farmers are completely powerless to decide which is to be adopted : perhaps one should say " which is to happen," for it is not clear that any body of people can make the decision ; it may be forced upon us by powers beyond our control. Some of the Russians have gone so far as to set up the Machine as a god to be worshipped : we have not yet reached that stage, though we all admit ourselves powerless to stay its progress and its devastating activity in making men superfluous. This is the great problem of our time.

THE EFFECT OF MECHANIZATION ON SOIL FERTILITY

By Sir E. J. RUSSELL.

Under the old four or five course rotation the fertility of the soil was maintained by four different processes:

(1) the straw was converted into farmyard manure.
(2) clover was grown once in four years, as far as possible;
(3) the roots and the aftermath of clover were fed off on the land by sheep which received purchased feeding stuffs;
(4) artificial fertilisers were given in the root break and sometimes also to each crop.

These four methods when properly worked sufficed to keep the land permanently in a good state of fertility.

On a four course rotation per 100 acres of arable land the annual yield of straw would be of the order of 80 tons, producing about 300 tons of farmyard manure and this would give a dressing of 10 tons per acre to the roots and leave a little over for the "waistcoat" of dung which the old farmers like to give to a piece of backward wheat. The dung together with the feeding of the roots and the aftermath on the land ensured a dressing of animal manure for almost every crop.

The reduction of the root area, and in the amount of sheep feeding on the land, has greatly reduced the amount of animal manure available and also it has reduced the amount of treading which the land receives.

Further, the change in method of feeding animals, whereby more use is made of grass and less of arable land, greatly diminishes the amount of farmyard manure available. We do not yet know whether farmers can afford to continue an exclusive grass system for live stock, with the resulting glut of fat stock in autumn and consequent low prices. But we have to reckon with a continuance of the system because of its cheapness and we must assume that the glut will be remedied by the simple expedient of lessened production.

These tendencies become more and more intensified as mechanization advances. It is, as Prof. Watson shows (p. 27) quite possible to combine a considerable degree of mechanization with live stock farming, as indeed we are doing on the Rothamsted farm, but we must recognise that over large parts of the eastern and south-eastern counties live stock and arable farming do not now work together

https://doi.org/10.23637/ERADOC-1-207

as economically as they did, and farmers are now trying instead machines and arable farming, in the hope of reducing their financial losses.

The problem thus arises: can fertility be maintained on an arable farm without the dressings of animal manure formerly given?

For some years past we have been engaged on this subject at Rothamsted and a considerable amount of information has now been obtained. We find that the importance of animal manure depends on the kind of crop.

Cereals

Wheat.—Our experiments on wheat have gone on ever since 1843, but in recent years they have been extended to deal more fully with this problem. The experiments show that yields of the order of 30 to 40 bushels can be obtained by the use of artificial fertilisers only, and without any organic manure so long as the cultivation processes keep the land free of weeds. The results are confirmed by the practical experience of John Prout of Sawbridgeworth, Essex, who, with his son William Prout, as a profitable commercial venture grew large acreages of wheat almost continuously from 1861 to 1911 on purely mechanized lines—one of the first examples of mechanization in this country. He occasionally took a red clover crop, but it is not at all clear that this was necessary although it was probably an advantage. He used no farmyard manure but artificials only, and his scheme of manuring was based on the recommendations of Dr. Augustus Voelcker, father of our present Dr. Voelcker[1]. There was no sign of deterioration of yield: for the first 19 years (1862–1880) it had been 32 to 36 bushels per acre, and for the 25 years 1880–1904 it averaged 35 bushels per acre, with 2 loads of straw. The average price during this second period was 31/9 per qr. for the wheat and 25/- a load for the straw: the average cost of growing (including 25/- per acre rent) was £6 8s.: the average return was £9 8s. 10d., leaving an average profit of £3 0s. 10d. So long as the straw was saleable at 25/- and grain and wages stood at their old levels all went well.

Mr. George Bayliss also grew wheat continuously without farmyard manure, but using a scheme of artificials based on Rothamsted results: here also the process was for many years profitable, and it was all done on purely mechanized lines[2]. Both Mr. Prout and Mr. Bayliss worked in the days of horses, and it was the growing cost of horse labour that finally drove them out of wheat growing. It is possible that they could have continued, had they so desired, by using tractors.

---

[1] For full particulars see "Profitable Clay Farming Under a Just System of Tenant Right," John Prout, 1881; and for the later years, W. A. Prout and J. A. Voelcker, Jour. Roy. Agric. Soc., 1905, *66*, 35.

[2] Described by C. S. Orwin, "Progress in English Farming Systems. III. A Specialist in Arable Farming." Oxford, 1930.

Barley, like wheat, is independent of farmyard manure and can be grown quite well with artificials alone. It was indeed included in the schemes of Mr. Prout and of Mr. Bayliss.

Our experience at Rothamsted has, however, brought out one important result which holds both for wheat and for barley: farmyard manure steadies the yield, and saves it from dropping so low in bad seasons as it is liable to do when artificials alone are given. Some of the results are given in Table I. This is generally true of all crops and it is one of the good qualities of farmyard manure not easily reproducible by artificials.

TABLE I.

FARMYARD MANURE COMPARED WITH ARTIFICIALS FOR WHEAT. BROADBALK FIELD, WHEAT EVERY YEAR, 1852–1930.

Plot No.	*Annual Manuring.*	*Average Yield. Bushels per acre.*	*Average difference between one year and the next. Bushels per acre.*	*Average difference as percentage of average yield.*
3	Unmanured ..	11.7	4.0	34.5
8B	Complete Artificials	34.5	9.3	26.8
2B	Farmyard manure	33.5	7.0	20.8

The general conclusion is that wheat and barley could perfectly well be grown with artificial fertilisers alone, and without farmyard manure, but at a risk of some depression of yield in bad seasons. This difficulty can be mitigated by using larger quantities of artificials, but we have no evidence that it is much affected by ploughing in occasional clover leys. (Table V).

Potatoes and Sugar Beet need farmyard manure or similar material

When we come to potatoes and sugar beet, however, the case is entirely different. It is not usually possible to obtain with artificials alone as good yields as when farmyard manure is used. Smaller dressings of farmyard manure can be given when necessary, but in that case the dressings of artificials should be increased, especially the potassic fertiliser. Examples from our results are given in Table II.

Mangolds and Swedes

Mangolds come into rather a different group. So long as yields of only about 25-30 tons per acre are produced, these can be obtained almost as well by artificials supplemented with rape dust or similar organic as by farmyard manure, and the cropping can be on the

TABLE II.

FARMYARD MANURE COMPARED WITH ARTIFICIALS.
LITTLE HOOS FIELD.

	Potatoes.—Tons per acre.		Roots—Tons per acre.							
			Mangolds.				Swedes.			
	Dung and Complete Artificials	Complete Artificials (larger quantity) without dung	Year	Rich Dung	Poor Dung	Complete Artificials	Year	Rich Dung	Poor Dung	Complete Artificials
Rothamsted—										
1921	3.6	3.8	1906	25.6	18.2	24.1	1904	15.7	13.1	12.2
1922	9.4	8.4	1911	17.1	15.8	14.2	1908	22.4	19.1	16.9
1922	9.4	8.3	1915	15.5	13.5	7.2	1920	21.7	18.4	16.3
1923	12.2	12.0					1926	21.1	21.8	15.5
1924	9.0	7.5								
Average	8.7	8.0	*Average*	19.3	15.8	15.2		20.2	18.1	15.2
*Seale Hayne** 1927	7.61	6.45								

* Equivalent artificials.

https://doi.org/10.23637/ERADOC-1-207

same land year after year. Our Barnfield has carried mangolds every year since 1876 excepting in two years 1908 and 1927 when the crop failed owing to bad weather.

The average yield for 50 years 1876–1928 has been, on plots receiving the best combination of artificials, in tons per acre:

	Artificials alone. Plot 4N (*b*)	*Artificials with Rape dust.* Plot 4 AC	*Artificials with farmyard manure.* Plot 2AC
Roots ..	17.8	26.1	27.6
Leaves ..	4.1	5.3	6.3

Where higher yields of 40 to 50 tons per acre are desired it may be essential to use farmyard manure.

Swedes can do without farmyard manure in regions where yields are normally only about 15 tons per acre or less: where higher yields are possible farmyard manure is required.

The return of the Straw to the Land

So long as any form of indoor winter feeding of animals remains profitable the straw can be made into farmyard manure, and this is the best way of using it. But if as commonly happens, the winter feeding is itself unprofitable one cannot charge the animals with much for the farmyard manure: at present prices of artificials I should not be disposed to allow more than 10/- per ton for farmyard manure. It is very easy nowadays to lose money over winter feeding.

For some years past at Rothamsted we have been trying to use the straw in some other way. Three methods have been tried.

(1) The straw has been ploughed direct under the ground. The immediate effect of this is to reduce the amount of available plant food in the soil because the micro-organisms that decompose the straw feed on nitrate and phosphate, just like plants, and so take up for themselves what the plant ought to have had. This does not much matter in the autumn, when the plant food might be washed out if the micro-organisms did not take it, but it is a serious loss in the spring when the young plant is ready for food. So far as our older experiments went—they were done on Broadbalk—the ploughing in of the straw even in the autumn was useful only on land short of potash and here its effect was very slight. The experiment is being repeated on broader lines to see if this is the general rule.

(2) A more useful method, which has been widely adopted in many countries by farmers who do not practise animal husbandry, is to treat the straw with the necessary food for the micro-organisms so that they can decompose it before it gets into the soil. This is the basis of the so-called Adco process, discovered at Rothamsted and developed on the large scale by the Adco Syndicate, Harpenden.

The resulting manure is quite good : some of their results are given in Table III. The practical difficulty on an English farm is usually to supply the water to wet the straw.

(3) A method now being tried at Rothamsted is to leave the straw on the ground and in autumn to drill over it a mixture of complete artificials, then to plough it under and let it rot.

In order to compare straw treated in these last two methods with farmyard manure a rotation was started on Hoos field in 1930, and is to continue for many years, in which the following are compared :

Farmyard manure.
Straw treated by the Adco process.
Straw left on ground, treated with artificials and ploughed in.
Complete artificials.

For the first two crops the two treated straws seem to be comparing very favourably with farmyard manure but we shall not be in a position to speak definitely about this till the experiment has run on for a longer period.

TABLE III.

CONVERSION OF STRAW INTO MANURE : FARMYARD MANURE AND ADCO.

YIELDS PER ACRE.

	Rothamsted, 1930.				Orsett, Essex.	Wye, Kent.
	Wheat. Cwt. per acre.	*Barley. Cwt. per acre.*	*Turnips. Tons per acre.*	*Seeds* Hay. Cwt. per acre.*	*Potatoes§ Tons per acre.*	*Mangolds§ Tons per acre.*
Adco ..	17.2	22.8	9.7	27.9	12.6	21.5
Farmyard Manure ..	15.9	16.2	9.0	22.5	11.9	21.0
Artificials alone ..	19.8	21.3	9.5	21.8	10.1	19.0
No Manure	14.7	11.8	4.2	10.9	—	17.5

* As dry matter.
§ Artificials added to the farmyard manure and the Adco.

Green Manuring

This is a very promising method of supplying organic matter to the soil ; it is, however, more difficult than is usually supposed.

In the older farming systems it was common to grow a mustard, tares or other crop and either feed them to sheep on the land or, if they were not wanted for the sheep, to plough them in as green manure. Many farmers however sowed the crop even when there was no likelihood of it being wanted for the animals : it was ploughed in. This green manuring is a recognised practise on light land.

The first serious tests in this country were made with mustard and tares at the Woburn Experimental farm, then under the Royal Agricultural Society, now part of the Rothamsted organisation. The soil is light, and was expected to respond well to green manuring but it did not : the green manure was entirely without effect.

For a long time this result was regarded as exceptional due to some undiscovered peculiarity. In 1920 and 1921, however, the Rothamsted workers, H. J. Page and his colleagues, made a number of experiments here and in different parts of England by aid of a grant from the Research Fund of the Royal Agricultural Society and only in few of these was green manuring successful.

Yet there is no denying that many farmers have obtained very good results with green manuring.

The subject has recently been fully examined at Rothamsted and an explanation of the discrepancy can now be given. Green manuring succeeds only when the time of ploughing in the green crop fits in with the time of sowing of the next one. The green crop must be allowed sufficient time to decompose and produce nitrates, but the following crop must be ready to take up the nitrate before it is washed out from the soil. Those farmers who succeeded with green manuring had got the timing right : others had not. Further experiments are being made to find out more precisely how to work out the timing but meanwhile green manuring should not be trusted blindly. If it is succeeding that is proof of correct timing, but if it is not known to be successful the timing should be looked into. Once this is right, however, green manuring becomes a valuable aid to mechanized farming.

The ploughing in of a clover ley in September in preparation for wheat in October seems usually to be successful, while the ploughing in of the June clover crop instead of cutting it, followed by a bastard fallow during July, August and September is probably the most satisfactory of all methods of keeping up fertility on a mechanized cereal farm, so long as *July, August and September are dry*. But if these months be wet most of the advantage may be lost. Green manuring is by no means entirely safe.

Fallowing

Recent Rothamsted experiments have shown that the old problem of the fallow is by no means cleared up. The Broadbalk wheat field has carried wheat every year since 1843 : never has there been a complete break. In 1926 and 1927, however, part of the field was fallowed : in 1928 the wheat grown after the two years fallow gave extraordinary yields.

C

	Plot.	1928.		Average 77 years, 1852–1928.	
		Grain. Bushels per acre.	*Straw. Cwt. per acre.*	*Grain. Bushels per acre.*	*Straw. Cwt. per acre.*
No manure since 1839	3	27.9	27.8	11.8	9.9
Complete artificials ..	13	55.2	32.0	29.2	30.8
No potash	11	56.9	31.4	21.4	21.8
No potash or phosphate	10	47.0	25.8	18.8	18.1
No nitrogen	5	35.2	34.8	13.6	10.6
Farmyard manure ..	2B	48.4	61.4	33.2	34.5

The result was a remarkable increase in the yield of grain. Never in the 86 years of successive wheat growing had Broadbalk grown a crop so thick set with grain, and we are unable at present to explain it. The season was very favourable, but probably not more so than some of the great wheat seasons of the past, 1854, 1857, 1863 1894, yet in none of these was so much grain produced. Much of the effect is probably attributable to the fallow, but whether the action is the suppression of weeds, the decomposition of vegetable and other matter, or some physical change in the soil, we cannot decide. Something more seems to be involved than an increase in plant nutrients, for no fertiliser scheme we have yet tested produces so remarkable a result. The effect lasted only one year, however ; the 1929 yield was about 10 per cent. below the average for the 74 years while in 1930 it had fallen about 40 per cent. below the average.

Even the sandy soil at Woburn was greatly improved for barley, but not so much for wheat, by two years fallowing ; the results, however, were not nearly so striking as on Broadbalk.

Under mechanized conditions fallowing would become relatively inexpensive and could therefore be practised. Our experiments suggest that a two year fallow may be much more effective than one year. The unmanured land on Hoos field gave in 1928 after one year's fallow only 10.5 bushels instead of the 28 bushels after the two years' fallow on Broadbalk. The subject is being further studied.

The effect of fallowing depends a great deal on the weather : crops following a fallow are therefore liable to greater variations in yield than those following another crop. This is well shown by comparing the wheat yield on Broadbalk where wheat always follows wheat, with the yield on Hoosfield where it follows a fallow : the average yield is raised by the fallow, but so also is the variation from season to season. (Table IV).

The "Golden Hoof" on Sandy Soil

It is a commonplace that light soils are improved by the folding of sheep, both the manuring and the treading being important. Apparently the manuring can be satisfactorily imitated but so far the treading cannot. Experiments at Woburn showed that the compacting of the soil by sheep is different from that produced by implements ; it extends to a greater depth and lasts longer ; the top three inches of the soil is mainly affected. It also gives a coarser tilth. In the experiments so far made it did not increase the water holding power of the soil, indeed, the trodden part was, if anything, somewhat drier than the cultivated part : the work, however, is being continued.

TABLE IV.

EFFECT OF ONE YEAR'S FALLOW ON SUCCEEDING WHEAT CROP. HOOSFIELD. ALTERNATE WHEAT AND FALLOW (NO MANURE). DRESSED GRAIN IN BUSHELS PER ACRE.

	Mean Yield.	*Average difference between one crop and the next.*	*Average difference as percentage of Mean Yield.*
After fallow in 1857, 1859 and alternate years to present time	14.2	7.4	52.2
After previous wheat crop, Broadbalk ..	11.7	4.1	35.1
After fallow in 1856, 1858 and alternate years to present time	14.2	5.9	41.4
After previous wheat crop, Broadbalk ..	11.7	3.4	29.5

TABLE V. COMPARISON OF CLOVER LEY WITH FALLOW AS PREPARATION FOR WHEAT.

AGDELL. FOUR COURSE ROTATION. WHEAT.
DRESSED GRAIN IN BUSHELS PER ACRE.

Plot No.	*Treatment.*	*Mean Yield.*	*Average difference between one crop and the next.*	*Average difference as per centage of Mean Yield.*
5	Unmanured, after fallow ..	24.0	9.5	39.4
6	,, ,, clover ..	22.3	9.6	42.9
	After wheat, Broadbalk ..	11.7	2.9	24.6
1	*Complete Artificials—*			
	After fallow	28.9	10.0	34.5
2	After clover	30.4	10.9	35.8
	After wheat, Broadbalk ..	34.5	7.2	20.8
	Minerals only—			
3	After fallow	28.1	9.2	32.9
4	,, clover	30.6	10.4	33.8
	,, wheat, Broadbalk ..	13.5	4.8	35.2

Conclusions

(1) For cereals no difficulty need be feared in keeping up soil fertility by artificial manures alone: farmyard manure is not essential. Artificials, however, are apt to give smaller yields in bad seasons than farmyard manure, though they may give better yields than it does in good seasons. Their range of yield is higher.

(2) Potatoes and sugar beet require for the best results farmyard manure or something that has the same action in the soil.

(3) Mangolds up to about 25 tons per acre can be produced without farmyard manure by using artificials and rape dust or similar substance. We have done this regularly on the same land each year ever since 1876. Larger crops probably require farmyard manure.

(4) Swedes up to 15 or 20 tons can be produced without farmyard manure: where larger crops are possible they probably require farmyard manure.

(5) Where animals are not kept it is possible to convert the straw into an effective manure by the treatment discovered at Rothamsted and taken over by the Adco Syndicate, Harpenden.

Experiments are being made with an alternative method of leaving the straw on the ground, drilling artificials on top of it, and ploughing the whole lot under.

The ploughing under of the straw by itself has not so far given satisfactory results.

(6) Green manuring as an alternative to farmyard manure is more difficult to practise successfully than is usually supposed: the ploughing in of the green crop has to be so timed that it supplies plant food to the next crop just when the crop needs it and not before, otherwise it is liable to be washed out.

(7) The treading of sheep on light land produces effects which the cultivation implements so far tried do not produce.

ENGINEERING DEVELOPMENTS AND POSSIBILITIES

By J. E. NEWMAN

Institute of Agricultural Engineering, Oxford

The cultivation of the soil and the gathering of crops require the expenditure of power. Power is measured by engineers in foot lb. per minute. A man can continuously exert 3,300 ft. lb. per min. A tractor developing 20 draw-bar horse power exerts 660,000 ft. lb. per min., that is, the man seated on the tractor has two hundred times the effective power that he would have if he worked with his own muscles.

There is the fundamental reason why agriculture is being mechanized. Just as the development of the petrol engine has made flying possible and the motor-car what it is to-day, so it has made the farm tractor an efficient and dependable machine, far more powerful and lighter in proportion to its power than it used to be. The fitting of air and oil cleaners, of large filters in the fuel supply, and of impulse starters, together with the general improvement in construction and engineering details which it shares with its cousin the motor-car, has made the tractor of to-day as different from most of those of the period just after the War as is the car of to-day from one eligible for the old crocks' race to Brighton.

Taking actual figures, in 1920, eighteen tractors were tested at the Nebraska Testing Station (and I think that the beneficial influence the Nebraska testing scheme has had on tractor design can hardly be over-estimated): their average weight was 448 lb. per D.B.H.P. At the Ardington trials in 1930, the nine paraffin tractors tested averaged 220 lb. per D.B.H.P. and the lightest tractor in proportion to its power, the Case L, weighed 158 lb. for each D.B.H.P. it could develop.

Those are big advances in ten years, but the advance in wearing powers, in expectation of life, in freedom from irritating minor troubles, in all-round handiness, in short, in general reliability, is much greater.

There is now quite a large number of makes from which to choose. Of makes which are being sold (I am not counting those, either home or foreign made, which no effort is being made to market), there are five tractors which develop 10 to 15 h.p. in the draw-bar, six which develop 15 to 20, and six more which develop 20 to 25.

https://doi.org/10.23637/ERADOC-1-207

Twenty D.B.H.P. hours are required to plough an acre of average land 5 in. deep, so that as a rough working rule the big tractors will plough an acre, the medium ones three-quarters, and the small machines half an acre an hour.

Just as the tractor is developing, so are implements to use with it being evolved. At first the tractor was simply used to pull implements designed for horses. Such implements could not be expected to make the most of the tractor's power. As Mr. Dudley said recently, "So long as you try to use a tractor as a mechanized horse, you will get nowhere." Now implements designed primarily to work with tractors are coming on the market. Thus there are drills 17 feet wide (in America drills up to 28 feet wide are used), there are rollers 26 feet wide, cultivators 16 feet wide, harrows 32 feet wide and so on; 4 and 5 furrow ploughs are becoming common.

Using such implements one man can plough an acre or more an hour, he can cultivate 50 acres a day and harrow 700 acres in a week; with another to help fill the seed box he can drill 7 acres an hour and spread fertilisers over 6 acres in an hour. And the daily rates can be doubled by night work, if necessary. All these things have been, and are being, done in England.

Such performances are so far removed from the ordinary ideas of rates of working, that they necessitate a fresh viewpoint, particularly when the cost of doing these things is considered. If the speeds are high, the costs are low.

On a farm equipped with such implements, 275 acres have been ploughed and planted this autumn in six weeks. The cost for fuel and labour was 7s. per acre, or, including depreciation 11s. per acre, and including the seed 20s. 6d. per acre. There were two men besides the farmer himself, one tractor, a 20 h.p. Caterpillar, all the time, and a Fordson part of the time. The land was medium loam, on the stiff side. There were no horses.

On Mr. Dudley's farm 58 acres were fallowed last year, half of it bare-fallowed and half bastard fallowed after a clover crop. All the work was done by his two 15 h.p. Caterpillar tractors. The clover portion had three one-way disc ploughings and a heavy harrowing, the other half was gone over ten times with disc ploughs, cultivators, pitch-pole harrows and ordinary flexible harrows and finally the whole lot was ploughed with mouldboard ploughs. The cost for fuel and labour was £37 8s. 6d.

Messrs. Alley Bros., on their farm in Norfolk last year, fallowed 550 acres, using two 20 h.p. Caterpillar tractors. These fallows were, considering the season, quite good; they were all sown with mustard which was ploughed in. Messrs. Alley have drilled 580 acres of wheat and propose to drill 100 to 150 acres of barley. I am not able to give their costs, but all their work, with the exception of some extra labour at harvest and the considerable amount they do themselves, has been done by a staff of four. Their tractors worked a little over 3,000 hours each in the year, which means that they consumed around 12,000 gallons of petrol, or 12 gallons per arable acre of their farm. This amount is higher, owing to the exceptionally large fallow acreage and the continual bad weather, than it should be in future years.

Take such figures and facts by themselves, and obviously they put a different complexion on corn growing in England, either with or without the combine.

It is perhaps worth while to give a list of the machinery required for a specialised cereal farm. Its size—the ideal size—is determined by the acreage which can be cut by a combine. On such a farm it will only be required to cut as much straw as is necessary to secure all the grain. Short and stiff strawed varieties will be planted. Under these circumstances 20 to 30 acres per day of 8 hours can be cut. As every effort will be made to spread out the harvesting period, there should be no difficulty in harvesting 250 to 400 acres with a single machine, according to its size. If it is proposed to work on a system of three years' cropping and one year fallow, then the acreage required is 330 to 500. Besides the combine, there will be required a tractor and plough, a cultivator to correspond, big harrows—the flexible type is best for tractor work, a drill either with or without fertiliser attachment—if without, a manure drill is required as well. A motor lorry is a necessity and so is a winnower and a grain dryer. That is the bare minimum.

For the 330 acre farm the implements would cost £1,500.

For the larger acreage, it would be advisable, and economical, to have a second smaller tractor to haul the drill and harrows.

The cost, including these extras, would be £2,000 to £2,500 or £4 to £5 per acre.

If bigger acreages are contemplated, the cost per acre falls off considerably. In fact, a 1,000 or 1,200 acre farm would not require an expenditure of more than £3,000.

These figures are subject to variation ; heavy land would require more tractor power. Fuel consumption would not exceed 6-10 gallons per acre, according to the class of soil. Yields may be expected to be at least as high as those prevailing in the district for land farmed in the ordinary way. So far, experience is that the deeper and more thorough cultivations, and perhaps the greater ability to do the various jobs at the proper time, which is a result of the speed at which they can be done, has produced crops above normal. Last year, Messrs. Alley had over 40 bushels of wheat per acre from a 105-acre field, and Mr. Dudley had 40 bushels of wheat from one field, and averaged 32. Mr. Nevile's barley averaged 32 bushels.

To deal with the combines. It is not generally realised how recent and how rapid has been the spread of the combine in Canada and the Great Plains west of the Mississippi. In the three Prairie Provinces of Canada there were only four combines in 1924, now there are over 9,000. Kansas had 3,800 combines in 1925, now it has nearly 30,000. Soviet Russia's grain growing plans are based on the use of combines and tractors. The two great factories of Saratov and Novo-Siberik are planned to turn out 35,000 combines per year.

The combine cuts out seasonal labour for harvesting. With means available, for drying the grain, its use is perfectly practicable in England, and the combination makes our climate an advantage instead of a handicap to the grain grower.

We can use the same machinery as is used overseas and we can, thanks to our climate, grow bigger crops. The dogma that we are incapable of growing more than a small fraction of our wheat requirements can be challenged.

The length of our straw is the greatest difficulty which combines have to face. If wheat growing extends in this country, the straw question will not be of such importance, as the market for straw is not capable of absorbing much more than it does now. Straw, however, can be handled in various ways. In the past harvest most of the machines left the straw in windrows, from which it was subsequently gathered by hay sweeps or hay loaders. One machine used a straw dumping attachment which left the straw in cocks, about the size of stooks. These were later loaded on to wagons by hand. Another machine used a straw spreading attachment. In this case, the straw was afterwards ploughed in or burned. Where sweeps were used, the straw was either ricked or swept straight to a baler. The adoption of a particular method has depended on local conditions, such as the machinery and labour available, whether the straw was to be consumed or sold, and the lay-out of the farm.

When the travelling baler, which moves along the windrows and bales the straw as it goes, is obtainable in this country, another way of handling the straw will be available.

The baled straw from the combine has been sold at the same price as baled straw threshed out in the ordinary way.

Combines are generally, however, unable to deal with straw over 3 feet or 3 feet 6 inches in length, unless they leave a long stubble or go very slowly. There are no inherent reasons why combines able to deal with longer straw should not be built and Messrs. Clayton & Shuttleworth's combine can do so.

However, the less straw is cut the more acres per hour the combine can do, and whether it will pay to cut all the straw and work more slowly, depends on the relative value of straw and grain. At present, in districts which grow long straw, and where straw commands a big price, those who wish to make the most of it should use binders. Where the straw does not grow so long, the combine user can bale and sell or use his straw just as does the man who harvests in the ordinary way.

One reason why some of the combines are unable to handle long straw is that the platform canvas is too narrow ; 36 inches is a standard size and some are only 30 inches wide. Consequently straw over that length cannot lie on the canvas. Bigger canvases present no constructional difficulties, nor should it be difficult to fit binder type beaters to combines, at any rate, for cuts up to 10 feet. They would be more efficient than the type now fitted, which can only be adjusted with a spanner when the machine is stationary. And a 10 feet cut is, in my experience, wide enough to keep any combine busy in a respectable crop. If the combine is travelling at 3 miles per hour, and averaging a 9 feet cut, it will, allowing for corners, cut 3 acres per hour. In a 40 bushel crop it would turn out 30 sacks in the hour. It could not do more if it had a wider cut; it would only have to be pulled more slowly. The International Harvester Company's new small combine is to have 5 feet and 7 feet cuts and a binder type platform and beaters.

There is the possibility that the future English combine may be a breakaway from present practice, possibly a push combine with cutter bar 5 feet wide and a drum of the same width straight behind it. The platform canvas would run from the cutter bar straight back to the drum mouth. Shakers and riddles would be the full width of the drum. There would be no canvas troubles, laid crops would cause a minimum of inconvenience, the feeding would be absolutely regular over the full width of the drum, and the straw and chaff would be spread out evenly and thinly on the shakers and riddles.

Drying grain is not really a difficult matter. The bare facts are that wheat will keep safely in sacks if it has 16 per cent. moisture or less, and in bulk if it has under 14.2 per cent. It will keep for a few days—long enough to send it to the miller—if it has 19 per cent. or 20 per cent. Ripe standing grain dries very quickly in sun and wind, 1 per cent. per hour is not an unusual figure. I am speaking of the removal of moisture due to rain or atmospheric conditions. Wheat may be 14 per cent. moisture one afternoon and 18 per cent. at 9 o'clock the next morning and down to 14 per cent. again or lower by the following afternoon. Wheat can be combined when its moisture content is as high as 30 per cent. In the ordinary way, however, the dryer is not likely to have to remove more than 6 to 8 per cent. and the bulk of the drying will involve removing only 3 to 4 per cent.

The dryers used by most of those who work combines are really much the same as the old kiln dryers, but the grain is only 5 inches deep and the air is driven through it by forced draught. The layers of grain may be vertical instead of horizontal—that is 5 inches thick instead of 5 inches deep; the principle is the same. In the dryer made by Messrs. Turner, and in the Sugar Beet and Crop Driers' conveyor dryer, the grain is continuously discharged, whereas in the home-made dryers (except one of Mr. Nevile's) the batch system is used. The latter are the cheapest in first cost and the former should be slightly more economical in fuel. These dryers handle from 1 to 2 tons of grain per hour, according to the moisture content. A 5 to 8 h.p. engine will drive the fan; and the furnace which heats the air consumes from 30 to 50 lb. of coke per ton of grain dried.

In planning an outfit, I think that if the dryer is capable of dealing with grain at half the normal hourly rate of the output of the combine, that is sufficient. In continued fine weather, when

https://doi.org/10.23637/ERADOC-1-207

the combine can work long hours, the grain will need little drying; in wet weather, when it wants more drying, the combine works only short hours.

It would not be right to leave the subject of corn growing without saying that the tractor binder, which can have its levers arranged so that the tractor driver can work them, and is operated by the power take-off from the tractor, is a great advance on the ordinary binder. It does not slip on wet ground, its wheels and the wheels of the tractor pulling it mark such ground less, and heavy crops are tackled more easily. Low bodied harvest wagons, such as are used by Mr. Hosier, are another means of obtaining economy. A load can be got on to them very quickly.

To return to the tractor, one of the outstanding questions is that of the relative merits of crawler or caterpillar tracks and of wheels. How far the advantages of tracks over wheels are worth their extra cost I hope the survey of mechanized farms, which the Institute for Research in Agricultural Engineering is carrying out, will be able to tell us in due course. The wear of Caterpillar tracks depends very much on the soil they are working on. On flinty or sandy soils it is heavy and fortunately it is on those soils that they are least needed; on the really heavy clay soils on which I should always choose to use them in preference to a wheeled tractor, if only because on such land they can be worked on many more days in the year, their wear is not excessive.

In one particular instance, on a soil rather on the light and abrasive side, tracks have done 3,000 hours' work before their pins needed turning, and their total life should be about 5,000 hours. On a clay soil I should expect their life to be 8,000 to 10,000 hours.

A combination of a big wheeled tractor and a small Caterpillar is in some cases a very useful compromise. The wheeled tractor will do the ploughing and heavy work, the small Caterpillar will do drilling, harrowing, manure distributing, and so on. It will be economical in fuel and there is no question of any damage to the soil or the crops. Spring corn can be drilled earlier than with horses. On the question of the padding of the soil, which used to figure so prominently in all discussions on tractors, it may be worth while pointing out that whereas a two furrow tractor pads half the ground it ploughs, a four furrow tractor pads only one-quarter. And when a tractor is pulling harrows 32 feet wide, the two feet it runs on are of relatively small importance, whether the tracks do harm or, as Mr. Davies' work at Wye suggests—and we have had similar experiences in our observation—good.

It is not certain that wheels are in their final stage of evolution. Spuds have, except on the product of that staunch conservative, Mr. Henry Ford, supplanted strakes. They pad the soil less. A wheel which will grip on stubble or on ground already worked, and which will run on the ordinary farm road or on grass without damaging them or shaking the tractor about, is wanted, particularly for the smaller tractors and the smaller farms. Some form of skeleton wheel should meet the case, or we may come to changing the wheels as necessary.

Before leaving the subject of crawler track *v.* wheeled tractors, it may be said that with wheels as they are, the two-wheeled tractor has probably already reached its maximum effective power. If more powerful wheeled tractors are to be built, then the four-wheel drive or bigger diameter wheels must be employed. Caterpillars, on the other hand, can be and are built in more powerful sizes. It is, however, doubtful if larger tractors than those now built would have any great field open to them in England. This is certainly true if light land is being considered. On heavy land a properly spudded wheel can get more grip and transmit more power. As it is on heavy land that extra power is needed, this, like the fact that caterpillar tracks wear least on the soils where they are wanted most, is an instance of providence favouring mechanization.

Is there a need for a smaller tractor than anything we now have? A tractor which will do two or three horse jobs, but is able to do them if necessary at high speeds? A tractor which will mow, pull a small binder, pull a tedder or rake, a drill or harrows and make itself generally useful? Such a tractor would be found plenty to do, particularly on a farm which was mainly grass. Even if it only pulled a single furrow plough, it could turn over quite a proportion of the small amount of arable on such a farm. Such a machine is likely to make its appearance this season, but while the idea is attractive, one must remember that the cost of such a tractor may be nearly that of the more powerful Fordson.

Mr. Hosier has been using old motor-cars to do light work, and there are distinct possibilities about the idea. They are cheap, and if only used for agricultural work, can be licensed as tractors. Fitted with chains, they get grip enough under bad conditions. For hay-sweeping he prefers them to the orthodox tractor. Any fairly heavy car will work a hay-stacker. When it is used in this way, it is better to drive backwards when hoisting, so that the load can be watched and the final flick, which jerks it a couple of feet further forward on to the rick, given at the right moment.

Motor lorries are used in Australia to distribute artificials. A whirling table and hopper, similar to the Wallace artificial manure distributor, are bolted on to the back of the lorry, and driven off a sprocket bolted to one of the back wheels. The manure is carried on the lorry and fed into the hopper of the distributor as it travels. As the lorry can be driven at high speeds, very big acreages can be covered, particularly under Australian conditions, where 84 lbs. per acre is an average dressing. I mention this as a matter of interest and not as a method I expect to see widely adopted here.

I only want to call attention in passing to the general use of motor lorries for all road work, as an instance that farmers are not so backward in adopting new methods, when they are of obvious utility, as some of their critics contend. And also to suggest that the motor lorry, from the standpoint of the student of farm organisation, occupies a very important position. It has taken over all road work from the horses and does extremely well what the tractor could never have done satisfactorily.

To quote an American authority: "Modern machinery is not tending to eliminate the family-operated farm, but is giving the farm family the opportunity to demonstrate its ability to meet changed conditions and continue as the best form of farm organisation for economic production, as well as for social welfare. In certain cases, however, family operated farms have increased in size as new machines have made profitable increases in the acreage which can be handled by the family." Mr. Fletcher was referring to the row crop tractor, which has become so popular on the small farms of the Middle west that the I.H.C. were in 1930 making 250 a day. The features of the row crop tractor are that its tools, such as drills, hoes and scuffles, are attached directly to its frame, usually in front of the driving wheels, where they can be seen by the driver, and in which position it is much easier to steer the hoes close to the rows accurately. The tools are lifted at the headlands by the engine-power. It has a high ground clearance and quick turning powers. With one of these tractors, and its appropriate implements, all the jobs, including root crop drilling and hoeing, mowing and binding, can be done single-handed. The range of equipment available even includes cultivating tools for lettuce. In Maine and Pennsylvania I saw potato crops, all the cultivations of which, ploughing, ridging, planting, hoeing and earthing up, spraying and lifting, had been done with these tractors. Cambridge University Farm will be trying one of them with a tool equipment this year and a number are already in use in England as ordinary tractors.

The tools and widths are adapted to American conditions. Some are unsuitable to conditions in this country, and the width of row is often greater than that preferred here. While it would usually be possible to adapt the existing equipment, a range of tools made in this country to suit our crops and conditions would greatly increase the usefulness of these tractors, particularly on the small and medium-sized farms for which they are intended, and in the market-garden industry. The Farmall was the original tractor of this type. Similar machines are now made by most of the leading overseas tractor firms, including the Case and Massey-Harris Companies; and the Farmall is being made in a larger size, corresponding to the well-known 22/36 I.H.C. Tractor. They are made with either three or four wheels, and usually the track width can be varied.

A report of a Committee of the A.S.A.E. on Row-Crop Equipments says that: "Farm machines cannot be made of rubber, to stretch to meet all variations of row widths. This being true, and row widths of the same and different widths varying greatly within small areas, row crop equipment costs more to produce and is more limited in use than would otherwise be necessary. The Committee propose to get more data on row widths preliminary to standardisation efforts." Quite a number of morals could be drawn from that statement.

How far any branch of agriculture can be mechanized depends on whether suitable implements to work with the tractor are available. Cereal growing already has such implements. So has grassland farming. Hay can be made without horses. The tractor power-drive mower, the tractor hay-sweep and the hay-stacker together make a most efficient combination as revolutionary in their effect on haymaking as has been the combine on corn growing. Others will speak of them and I only want to say that the power take-off drive and the safety clutch have made the motor mower a thoroughly good tool, and that all the users of hay-stackers whom I know are pleased with them. The objection to silage-making, the heavy weight of the green material, is largely discounted when tractor power is used to move it.

I have mentioned the row crop tractor and its use in potato growing in the U.S.A. It should be equally successful here. But a real harvester is wanted. To lift the potatoes out, and then drop them back on to the ground again is wrong. It ought to be possible to drop the potatoes into some vehicle, which would be emptied on the headland. The same thing is true of sugar beet, and possibly of mangolds, which in some ways would be much easier to lift mechanically than are beets. But speculation is easier than achievement. Still, when one considers the advances made in the last few years, and the possibilities ahead, I think the confidence of those who feel that mechanization provides the means by which agriculture could do more than any other industry to redress the balance of trade has sound foundations.

COMBINATION OF LIVE STOCK WITH SYSTEMS OF MECHANIZED FARMING

BY PROF. J. A. S. WATSON
School of Rural Economy, Oxford

I FEEL sure that I need not, before an audience of this kind, labour the point that live stock constitutes a most important branch of English agriculture. The last estimate[1] that was made put the value of the annual output of live stock and live stock products at £155 millions or 69 per cent. of the total. Against this the value of the corn, potatoes and sundry farm crops sold on farms was £46 millions or about 20 per cent. of the total.

Neither need I say that for the past century and a half arable land has fulfilled a very important function in the live stock industry. A hundred years ago indeed it would have been more appropriate to look at the matter from the opposite point of view—to discuss the function of live stock in relation to corn growing. Even to-day there are districts where the cash crop is the main object, and stock is regarded as the subsidiary thing. But if we take the country as a whole and regard our problems from the national point of view we must, I submit, bear in mind that the live stock constitutes our major and the cash crops our minor concern.

The main function of arable land in relation to stock is the provision of winter food. Thus the arable farms of Norfolk and Lincolnshire have functioned as the complement of the store pastures of Ireland and of the fatting pastures of Leicestershire. The arable sheep districts have supplied our markets with early spring lamb and with winter mutton, while the hills have bred the stores, and lowland grazings have yielded the main supplies for the summer and autumn markets.

The recent decline in our arable area has upset to some considerable extent the balance formerly arrived at. There is now a shortage of meat in the spring and early summer. Graziers complain that the supply of stores in spring is inadequate to the areas of grass that have now to be stocked. On the other hand there is an increasing glut of half fat cattle and lambs in the autumn. If now we are

[1]The Agricultural Output of England and Wales, 1925.

https://doi.org/10.23637/ERADOC-1-207

to have a revolution in arable farming, and if this is to imply the virtual disappearance of stock from large parts of the old arable area then the maladjustment between the supplies of winter and of summer keep will be aggravated.

In a considerable proportion of the arable farms that have so far been mechanized the system adopted is one of specialised corn growing; weed control is effected by means of a bare fallow; for the maintenance of fertility sole reliance is placed on artificials; straw is sold or ploughed in and no live stock—at least neither cattle nor sheep—is kept. We must, I think, consider whether mechanization necessarily involves so radical a change in our traditional system of farming.

No one can of course deny that mechanization must involve rather drastic reorganisation. For one thing mechanization can fully achieve its object, that of a really big economy of labour—if each enterprise is carried on upon a large scale. We cannot yet put this into very precise terms, but it would seem that the minimum area of corn is some two or three hundred acres and of hay between one and two hundred acres, while the minimum size of a dairy herd is about 60 cows. Each department necessitates the use of large and generally costly special machines. Clearly then, except on very large farms the number of enterprises must be limited. The inclusion of non-mechanized crops with large seasonal labour requirements will be difficult or impossible; the labour will not be available. The practical question then is how far the system can be diversified without departure from the fundamental principle which is, as I see it, to reduce the labour cost of the commodities which we produce. Let us consider present possibilities and hazard a few guesses about the future.

The hay crop, which is common to both arable and grass land, and is now our largest single source of winter food, can now, under most circumstances, be most completely mechanized—cut, windrowed, swept up and stacked by mechanical power. Indeed (given a large enough area and the absence of the obstacle of ridge and furrow land) the case for mechanization is even stronger than that of the cereals. Tractor sweeps and stackers of several makes are on the market. They are, relatively speaking, cheap. For hay making the tractor is not only faster and more powerful but also handier and more adaptable than the horse. Even the difficulty of a large capital investment in the form of tractors can be avoided, for it has been shown that second-hand motor cars can be cheaply adapted to the work and are perhaps actually more suitable for sweeping and stacking than the conventional type of general-purpose tractor. An alternative plan, where the hay has to be taken out of the field where it has grown, is to bale straight from the windrow, but whether this will work in our climate, over an average run of seasons, is perhaps yet to be demonstrated.

The root crops—mangolds, turnips and swedes—represent the other extreme of the problem. Even where these crops are grown as part of a complex system, and some of the operations can be regarded as fill-time jobs, the cost in man and horse labour is frequently out of all proportion to their food value. It is only by placing fantastic values on the secondary benefits that one can show anything approaching a balance. The real cost of the crop when pulled and carted is perhaps as often over as under a pound a ton ; it takes some twelve tons of roots to yield the same food value as a ton of maize meal and the latter can be at present delivered on our farms for about £6. With hay and corn mechanized there will be neither hand nor horse labour available to work any considerable breadth of root land. Our area of these crops has shrunk by roughly 40 per cent. since 1914. Mechanization of the laborious processes of singling and harvesting has as yet made little progress. The mechanization of other crops can only hasten the decline of root growing. I know that in the best root districts the picture of the economics of the crop is not so black as I have here painted it. But one must speak of average conditions.

I have far more hope for the kales. Let me indicate what I believe are their advantages and possibilities. They can produce full crops without anything like meticulous singling. They can, without loss of yield, be planted in wider rows than roots and are hence better adapted to quick intercultivation with the row crop type of tractor. They have a greater smothering effect than roots. They are more reliable as to yield, and will repay more generous treatment (especially in regard to nitrogenous manures) than turnips or swedes. Finally, their mechanized harvesting, where they have to be removed from the ground, seems to offer a comparatively easy problem to the engineer. The construction of a machine to cut and bunch the plants would not seem to be inherently more difficult than that of cutting and binding maize—which has been satisfactorily solved. A higher degree of winter hardiness would indeed be an advantage. Possibly a small acreage of silage would be a necessary insurance against frost damage to the kale. Even so, a combination of late sown rape, kale and silage would seem to provide an alternative preferable to that of the bare fallow in mechanized arable farming.

The next problem is that of the dung cart. Under certain conditions, of course, the problem may be dodged. On land suitable for outwintering cattle or for the Hosier system of dairying hay may be consumed where it has grown, and straw and forage crops probably very near to their source. Recent work at Aberdeen suggests that outwintering has certain actual advantages over house feeding, and I see no particular reason why it should not be applied to fatting cattle as well as to stores. I am assuming a short ley and that the stock would be wintered on this.

Sheep folding is another means of returning fodder crops and hay to the land. I do not suggest that a mechanized farm is a place for an arable breeding flock. I am not sure that there is any place left for one. The elaborate succession of crops, each on a small area of land, the performance of close folding and so forth do not fit in with the scheme of things. It has always seemed to me that where such a flock is kept everybody on the farm becomes a slave to the sheep and everything has to give way to their demands. But it is a very different matter to use roots as they are used in the northern counties, for fattening tegs or as a supplement for grass land ewes, giving a big "break" at a time. The labour charge is a small fraction of that which is involved in the old system of all-the-year-round close folding.

But sheep do not solve the problem of disposing of straw, and I cannot help feeling that this is a real problem. I cannot reconcile myself to the idea of ploughing it in, while there are thousands of hungry cattle to be fed. And I feel that any general suggestion of selling it is merely begging the question. There is a shrinking market for straw outside our own industry, and we cannot live by taking in each other's washing. You may say that the grassland farmer is a customer, and that it will be part of the general process of specialisation that he should rely more upon the arable farmer for his supplies of straw. This is probably true as regards the dairy farmer, but as regards the winter feeding of cattle other than dairy cows the question is whether it will be more economical to take the food to the stock or the stock to the food—in other words, which is Mohammed and which the mountain. Moreover, supposing that muck is a grossly over-rated manure (which I do not believe), it is still of far more use to the arable man than to the grassland farmer.

Sir John Russell has already spoken on this question of the maintenance of fertility, but I hope he will forgive me one observation on this question of the value of dung, and of humus in general. It is this, that the value of organic manures depends tremendously on the kind of soil that one is dealing with. This was impressed upon me from my earliest days. On one side of me was the Carse of Gowrie, an area of deep rich heavy silt, low lying and nowhere far above a permanent water table. There the farmer can, and sometimes does, follow wheat with oats and hay, sell the lot and carry on. You cannot, to use our local phrase, "tear the guts oot o' the land"—it is all guts together. But on the Old Red Sandstone gravelly loams, which adjoin there is a different story to tell. The man on such soil who keeps little stock and sells his hay and straw very soon farms his land out, even if he is liberal in his use of artificials. I think we must not too hastily assume that we can, even now, anywhere and everywhere, abandon stock and place our trust in chemical manures.

If land is unsuited to outdoor winter feeding, and at the same time needs organic manures we have undoubtedly a difficult problem. I do not know what the solution is, but we must not give it up.

Let me conclude by briefly sketching out an example of the kind of system that I have in mind. We must have some six hundred acres of arable land, or rather more if it is poor stuff. Additional grass, as I see it, will be no disadvantage, but rather the contrary.

Suppose the soil to be a medium shallow loam, the climate neither wet nor very dry. Suppose, too, that the land can be fenced and watered. Now arrange the land for a five course rotation including two corn crops, a two years ley and, for the fifth division, a combination of rape, kale and silage with perhaps a bit of fallow when necessary. The corn crops will be " combined " and the straw swept up and stacked in the field. The first year's seeds might be hayed and the crop mostly consumed on the land during the succeeding winter, along with straw and the kale and silage. The ley could be grazed with cattle or with grassland sheep during the second year, and then ploughed under—you may fill in the details and modify the scheme here or there far better than I can. The emphasis might be placed more on corn or more on stock ; a greater or less proportion of hay and straw might be sold according to experience. The scheme need not be hard and fast. But I suggest that in its elements it is a workable alternative to the stockless mechanized farm.

DISCUSSION

Mr. G. H. Nevile (Wellingore).—I am glad to see that Professor Watson dealt with the combination of live stock farming with mechanization, because I feel that there has been a tendency to regard power farming as applicable only to specialised grain farms. It is true we must look for a new arable system to take the place of the four course rotation, which has been our stand-by for so long, but farmers are a conservative race, and few can see their way to eliminate live stock entirely from their holdings.

Mr. Newman has dealt with the engineering aspect of specialised farms complete with the most modern machinery, but I should like to touch on equipment for those of us whose enterprise is limited by the good-will of our Bank Managers, and who are in the transitional stage, and gradually altering our systems from horse to power farming.

Our aims are to save £1 per acre in the preparation of our land by substituting tractors for horse power, and by the use of the combine harvester, dispense with the harvest and threshing gang, and possibly save a further £1. in the cultivation of our corn area.

The size and cost of our equipment will largely depend on our land, and on the rotation for which it is best fitted.

In any rotation we may adopt, we have to give due consideration to the maintenance of the fertility and cleanliness of the land, but modern implements capable of ploughing 10 or 12 acres a day, and cultivating or disc harrowing a proportionately greater area, alter our outlook both with regard to costs and the rapidity of work, and it should be our object to compress both the cleaning effect of a root break or bare fallow, and the fertilizing effects of a clover crop, into a single season.

For this reason the three-year rotation where two corn crops are followed by a renovating year, appears to me a practical and simple one, and economic of equipment. A winter cereal followed by a spring cereal undersown with trefoil or trefoil and rye grass, would then be our cropping. The trefoil would be ploughed in from the middle of May onwards, and if cleaning is required there would be time for a bastard fallow before sowing the wheat in September or early October, and thus ensuring a strong plant before winter.

If in place of wheat two spring cereals are grown, cleaning crops for sale such as potatoes or sugar beet could be taken on part of the area in place of the trefoil mixture. If grass land is held with the arable area, some proportion of the third year crop can be devoted to

https://doi.org/10.23637/ERADOC-1-207

roots suitable for the grass land live stock. These may be marrow stem kale and mangolds for dairy cattle, or marrow stem, thousand headed kale, or rape, sown thick to act as a smother crop for sheep food.

In this rotation 66 per cent. of the area is devoted to cash grain crops, but on moisture holding soils in clean condition it may be possible with the aid of artificial fertilizers to devote 75 per cent. or 80 per cent. of the land to such crops. In these cases the time available for both cultural operations and harvest is cut down and a larger equipment may be necessary. This point is intensified by the fact that such rotations will be more suitable for our stronger lands.

Naturally, the strength of the land will have a great bearing on the size of the power unit which is necessary, and I suggest that in studying this point, we can best classify our soils by the number of pounds draw-bar-pull required per square inch of furrow turned.

In the case of my own farm, I have some heavy silt on the Lias Clays where, in its toughest condition, the draw-bar-pull may amount to 20 lb. per square inch of furrow turned. Here a 20 h.p. tractor has a difficulty in ploughing more than four acres a day, though on the same fields after a dry summer when the land is thoroughly cracked, we have ploughed 10 acres a day. On the lightest of my barley loams on the Oolite escarpment, the pull is no more than 6 lb. per square inch, and the same tractor will plough 10 and 12 acres a day under almost any condition of weather. Good medium loams average about 8 to 10 lb. per square inch, and the bulk of the prairie wheat lands in America where a 20 horse tractor is expected to handle four—14 in. furrows with a ploughing output of 12 acres a day, have a pull of 7 lb. to 8 lb.

Until recently the small tractors giving about 10-12 rated draw-bar h.p. with a total draw-bar-pull of about 1,250 lb. on their working speeds of 3 miles an hour have been the commonest in this country. I consider these uneconomic on all but the lighter lands, as their daily output is insufficient to get over the land in time. For secondary cultivations they are useful. When a farmer already has a tractor of this type and is contemplating a larger unit, he will do well to retain his old tractor as a standby and for secondary cultivations, straw and hay loading, and similar work.

The most efficient size tractors for this country appear to me to be the medium sizes of 20-25 h.p. on the draw-bar with a pull of 2,500 lb. at three and one-third miles an hour. The capital cost is substantially less per h.p., and as their ploughing output is double that of the smaller type, the wage cost per acre is halved. They are capable of handling a combine with an 8 ft. cutter bar driven from the power take-off which the smaller sizes cannot do.

In the case of wheeled tractors with standard wheels, I think that 25 draw-bar h.p. is about their limit of utility. Fully loaded at this power they have difficulty in getting a grip on light land in secondary cultivations, and on heavy land in moist condition, their compressive effect may be definitely bad.

Track-laying tractors have not this defect. Their first cost, however, appears to be nearly £200 more than similar sizes of wheeled tractors, and I think it is a weakness that they are geared considerably lower than the wheeled types. To get the same acreage per hour from them, therefore, requires extra large implements. For secondary cultivations and working on heavy or wet soils, they are much superior to the wheeled types.

The cheapest load for a tractor is that when it is delivering just its rated h.p. without overloading. To fully load even the 20-25 h.p. tractors on medium and light ground really needs special equipment, but in the transitional stage, we must think twice before embarking on more expensive implements. Where the 10 h.p. tractor can take 3 furrows of 10 in. or 11 in. at 3 miles per hour, a full load for the 20 h.p. tractor would be 6 furrows, but I suggest that in these cases use should be made of the top speed of the tractor, and with four—12 in. furrows at nearly 4 miles an hour we can cover a lot of ground. In America the four-furrow plough with 14 in. furrows and digger or semi-digger breasts seems to be the standard equipment. In the 14 in. sizes, the output per day is put at 12 acres. Personally, I am well satisfied with a 4 furrow plough where the furrows can be altered from 9 in. to 12 in., and a furrow taken off where necessary. This, combined with the use of the top speed on light land gives great flexibility, and a wide range of usefulness. On the heavy land the plough can be shut down to three 9 in. or 10 in. furrows, and a full load can be obtained on the lighter land by ploughing in top gear. At the higher speeds the furrow is more broken, and personally I like the greatest amount of disintegration possible where the soil is suitable.

There still seems a disposition to take the horse's speed of 2½ miles an hour as the ideal ploughing speed. On heavy wet soils where the object is to get rid of moisture, the well set up furrow may be advantageous, but on our light barley soils which suffer from drought, it appears to me that the broken, moisture retaining, furrow, is an advantage.

Similarly with our secondary equipment, while in the transitional stage, we wish to avoid purchasing extra large disc harrows, rolls, drills, harrows, etc. I suggest that this may best be done by harnessing our implements in tandem fashion. For preparing a seed bed this year a 20 h.p. tractor took a three-horse roll, a set of disc harrows and straight tooth harrows in tandem, working round and round the field, followed immediately by a lighter tractor with the ordinary drill. In this way I was able to cultivate and sow up to 25 acres a day with two tractors and two men at a cost of about 2s. 6d. per acre. Sowing immediately behind the harrowings appears to me to give the best results.

We may put the daily cost in round figures of running a 20 h.p. paraffin tractor at 30s. This allows 7s. for the driver 10s. for depreciation, and 13s. for fuel, oil and sundries. Such a tractor should have a life of 1,000 days, and at 10s. per day, we are allowing £500 for depreciation and repairs on a tractor costing about £350.

The ploughing output may be 10 or 12 acres a day in light land, and 4 acres in very tough soils, so that the cost would vary between 2s. 6d. and 7s. 6d. per acre, with 4s. to 5s. as a fair mean. In secondary cultivations 20 acres a day should be possible for roll, disc harrows and harrows worked tandem fashion, or 1s. 6d. per acre. With seeding and distributing artificial manure a total of 10s. or 12s. should cover the cost of planting a corn crop in medium soils. Mr. Newman's figures of 11s. per acre for cultivations for wheat, confirm this view. If we allow 5s. per acre for depreciation on the combine, we may put all harvesting charges at 15s. to 18s. per acre. This covers combining, drying, final sacking for market and transport to station, so that 25s. to 30s. should cover our cultivation costs, with the exception of handling straw. To this has to be added the cost of seed, artificial manures, rent, general expenses, and a share of the cost of fallowing, to arrive at the total cost of the crop.

Looked at in another way, the sum of 25s. to 30s. per acre for cultivation costs will be found to be made of approximately equal shares for wages, fuels, etc., and depreciation. This gives us a measure of possible economies. Wage costs can be reduced by a few shillings if more capital is devoted to field and barn equipment.

As regards fuel, 7 or 8 gallons of paraffin per acre should, I think, provide for all the cultural requirements of our arable area, and with this at 6d. per gallon the use of electricity, promises little, if any, further economy when the cost of installation is considered. The petrol tax makes the use of this fuel prohibitive, and more than doubles the fuel cost. There is an undoubted future for crude oil engines both in the cost and the efficiency of their fuel, but the engines must compete in price and reliability with the present paraffin tractor before they can replace the latter.

Combine Harvesters have only been tested out in this country in the last three or four years, but Mr. Newman's figures show that their general utility is proved, and that they are no longer in the experimental stage. They vary in size from those that harvest a 35 foot swath of grain to those which cut an 8 ft. swath.

For this country the larger sizes are not likely to be economically useful, and the 8 ft. to 16 ft. sizes are probably those which will best meet our needs. Purchasers would do well, I think, to specify for a smaller length of cutter bar than that in use in America. That is to say, if they contemplate taking a 12 ft. cut, they should order the 16 ft. size combine, and use only the 12 ft. bar, while for the 12 ft. size combine, the 10 ft. cutter bar is ample : this allows for more margin in the drum, riddles, and straw handling sections. Both beater drum and peg drum types are in use. The peg drum types thresh the grain quite as cleanly and with as little damage to the grain as the beater drum types.

For handling the straw again two types are in use, a rotary system and the ordinary straw shaker type. The former is reputed to give better results in hilly land, but from what I have seen I think the shaker type riddles out more of the grain that has been carried over with the straw, and there is less loss of grain.

The 8 ft. size of machine is made to work off the power-take-off of a 20 h.p. tractor, and for larger sizes an auxiliary engine on the combine drives the cutting and threshing mechanism, and a tractor of 15 h.p. is suitable for the haulage. The larger machine has two engines, and a crew of three men, as against one engine and two men on the 8 ft. size, but I have formed the opinion that the greater flexibility of the larger machines more than repays the extra capital and working costs where the acreage is at all extensive.

Windrowing in America has largely extended the usefulness of the combine. In this system the crop is cut at the time when it would be ready for the binder and left for a few days in windrows 2 ft. to 3 ft. wide on the top of a high stubble, so that with wind passing freely through the windrows, weeds and unripe corn may wither and dry out. The combine with a pick-up attachment in place of a cutter-bar then goes over the field again and threshes the grain. Possibly influenced by two exceptionally wet harvests, I have formed the opinion that where a dryer is used, the windrower is an unnecessary expense, and I should prefer to leave the grain standing till fully ripe, and leave the dryer and dresser to dry the corn and make a good sample.

In weedy fields, or where clovers have been under-sown and some are cut with the corn, it is impossible to separate all green leaves and pieces of stem from the corn as it comes from the combine. This green trash carries much moisture, which is rapidly taken up by the corn, and may increase its moisture content by 5 or 6 per cent., and so would prevent safe storage. If a drying system is in use, this material is easily blown out as soon as it is dried. Upstanding crops of wheat cause little trouble and are easy to combine, but where barley is left till fully ripe some is sure to be storm broken, and the crop must be cut low to get as many heads as possible. This makes the cutting of a considerable amount of trash inevitable.

I think that while we are still in the transitional stage more attention is given to straw than will eventually be the case when our live stock management is adapted to power farming. We are still inclined to aim at obtaining the close binder stubble, whereas, as time goes on we shall aim at cutting as little straw as possible, and ploughing the remainder in direct. Cow keepers and poultry men are now finding peat moss litter a cheap substitute for straw.

Much green trash considerably delays combining. With upstanding crops of wheat I have on several occasions cut 18 acres in a day with a 10 ft. cutter-bar, but for barleys 11 to 14 acres has been a more average figure. In storm broken crops the least dampness in the straw makes it tough, and it does not readily slide up the long points, and is consequently pulled up by the roots and causes stoppages. The steep angle of the long points owing to the height of the cutter-bar is a detail that should be improved on the combines with which I am acquainted.

Grain Driers are, I feel, a necessary adjunct of the combine in this country, and Mr. Newman has dealt with these, but they should I think be designed to dry the full output of a combine at the same rate at which it is cut, and should have a capacity of 30-40 cwts. an hour. Drying and dressing for market should in my opinion, be one operation, and few barley samples come direct from the combine in a saleable condition, though wheat may do so. The tray drier, taking one ton lots of corn, and handling about 60 qrs. a day seems to me the most foolproof and cheapest in first cost, though it takes more labour than is the case of continuous process plants. Where a machine is in use for only 30 or 40 days a year, however, economy in operation may be counterbalanced by increased capital cost. The tray drier has the further advantage that it will dry other crops as well as grain.

As Mr. Newman says, the capacity of the combine harvester appears to be the chief factor in determining the most economical combination of land and power. A combine with a 10 ft. or 12 ft. cut should command 400 acres of grain crops under our conditions. This implies a total area of 600 acres of arable under the three year rotation, or 800 acres under a two year rotation. In harvest years like 1928 and 1929 the area commanded would be 50 per cent. greater.

In America it is stated that a farmer should not have more than 5 dollars an acre invested in machinery under Montana wheat conditions of half wheat and half fallows, and in some of the larger farms the figure is reduced to 3 dollars per acre.

There it is considered that a four-plough tractor (say the 20-25 h.p. sizes) can economically work up to 1,100 acres. This size tractor costs at present about £350. For plough, cultivator, disc harrows, harrows, drill, manure distributor, etc. we may allow a further £250. The combine harvester, dryer and dresser should not cost more than £550, so that the main items of our equipment should be available for about £1,100 to £1,200. This outfit would command 400 acres of corn and 200 acres of fallows on a three year rotation. For hay and straw, collecting implements, hoes for roots, etc., I am considering that the implements at present on the farm would suffice, and that a motor lorry can be hired for grain transport at harvest time.

In some quarters stress has been laid on the small size of English fields as being a hindrance to power farming. Large fields are no doubt preferable, but I can see no economic justification in the present stage of our knowledge for a wholesale grubbing up of hedges.

Rent, fuel, manures and seeds cost the same per acre whether fields are large or small. Labour forms but a small item of our total cost. Ploughing small fields in bouts with constant turning on the headlands is wasteful of time, but this may be got over by ploughing round and round the fields.

Where the combined harvester has to be dismantled and re-erected when changing from one field to another, a further loss of time takes place, but this can be measured in minutes. The chief loss is in keeping the fences trimmed, but fences are necessary where any live stock are to be kept, in a system of alternate husbandry, and although their care may cost us 2s. or 2s. 6d. an acre per annum, the expense is justified if their retention enables us to utilise for live stock, the area which would otherwise be bare fallow.

Another stumbling block in the way of mechanized equipment is its capital cost at a time when farmers' resources have been reduced to vanishing point. If I am right in my contention that £2 or so per acre is sufficient in fair-sized farms to provide the essential equipment, and that a saving of a similar amount per acre of corn grown can be obtained by this means, it appears to me that expenditure in this direction will be much more productive than a similar amount spent or locked up in live stock for winter feeding under the four-course system.

My advice is—sell some stock to buy a harvester, and save money to buy stock when meat shares in the 10 per cent. tariff.

Lord Lymington (Farleigh Wallop) stressed the importance of Professor Watson's figures showing the relative importance of cereal as against live stock products in the total value of the output of Great Britain. He further added that the imports of live stock products into this country (which he said we are quite capable of producing ourselves) amounted to some £200,000,000 and these products, if produced at home could give employment to 500,000 people ; while the value of our imports of cereal products was only £100,000,000, no more than one-third of which we could produce for ourselves. Lord Lymington went on to say that if tendencies were to be judged in order to prophesy for the future, extra cereals for sale off the farm would probably be produced by mechanization with far less employment on the land than there is to-day. As far as his own experience on a mixed farm was concerned, and especially since his acquaintance with caterpillar tractors was of very recent date, he was not prepared to lay down any figures for costs. He had had no opportunity, and he believed very few other people had either, to ascertain the true amount to be charged for depreciation in the implements, and the regulation of overhead costs was by no means as simple as it seemed. In addition, the shape of the field played an absolutely essential part in the ascertaining of costs. For instance, he had found that the cost of ploughing a thirty acre field varied from 3s. 3d. to 6s. 1d. an acre ; the variation being due not only to the strength of the soil but to the amount of corners in any particular field. Until he had done accurate costings over some years he would not be prepared to give any figures based on a scientific valuation.

Another point he wished to emphasise was that mechanical farming is in the hands of a few pioneers some of whom rightly were intimately connected with implement makers and whose repair and depreciation accounts might therefore be greatly lessened. Also where people with considerable capital were doing a great deal in the way of experiment their costs might quite unconsciously be varied by a tendency to confuse experimental accounts with running costs. Therefore nothing was more misleading than to delve into the question of costs until these had been carried out accurately by practical farmers for some years. For this reason he made no excuse for going away from the engineering side of which he had very little experience in comparison with many others at the Conference, and making some remarks as to the general direction to which mechanization was leading.

For himself the introduction of mechanization for the production alone of cereals for sale off the farm seemed to be the magnum opus of antichrist. For this reason—that every nation in the world was lamenting that it had lost, or was tending to lose, the balance between industry and agriculture which was the fundamental root of the people's lives. As an extreme example he quoted the case of certain farming operations in Canada where the tractors came across the border in the Spring, ploughed up waste land in hundreds and thousands of acres, planted a crop, left the land uninhabited until the Autumn when combine harvesting machinery arrived, took the harvest and went away leaving the land again derelict until the following Spring. Thus, Lord Lymington said, if mechanization was going to serve the health as well as the pockets of the people, it must be capable of giving more rather than less occupation on the land. If Mr. Dudley's experiments, from which he had learned so much and to which he owed so many thanks, proved that mechanization, perhaps with the help of a wheat subsidy, was only going to develop the growing of cereals for sale off the farm, they would probably cost the Nation more than they were worth. If, however, they were part of the large whole and would enable us to produce more live stock, to save the imports and to give the employment he had envisaged at the beginning of his remarks, then with stability of imports and without raising the cost of living to an industrial population we could be assured of health and safety on the land.

Lord Lymington followed up this point by saying that he was not sure that the future of the combine harvester in this country—though it might be imminently useful for crops like malting barley—was going to be the mechanical development that would save English agriculture because of two things. First, the weather risks in which the crop had to grow from the winter sowing to autumn harvesting and the consequent tendency that the heavier your crop was, the more likely it was to be lodged : and secondly, the extra expense in bad weather of getting in the harvest as compared to the harvesting operations in the New World. And in addition to that in most circumstances the threshed grain required drying.

Therefore, Lord Lymington said, he would like to put the following problems as those demanding immediate mechanical solution for the health of the industry.

Our climate is not only capable of growing better live stock, but of producing more crops than almost any other in the world with the exception of New Zealand. Thus if, instead of long straw crops of which perhaps, three, in four years, was the maximum for which one could hope, implements could be developed which could be used throughout the summer for the purpose of harvesting all sorts of catch crops ; one would have a spread of the capital cost of the implement over the widest amount of working time combined with a large cropping possibility. It was a well-known scientific fact for instance that young grain of all sorts as well as young grass and lucerne at the height of 8-12 inches produced more fodder value for animals than did the harvested grain in the long straw. The land could be kept cleaner and one could average probably two crops a year instead of three crops in four years. This postulated a drying plant whose value for agricultural purposes would be incalculable. In the second place in connection with mechanized farming its only special value apart from the cheapness of production lay in its ability to limit casual labour, the least desirable of all forms of labour. Now animals, whether one milked mechanically or fed pigs by electricity, required personal attention and demanded special knowledge which is the foundation of agricultural lives and the basis of agricultural employment.

The business, therefore, was to get rid of casual labour in connection with the keeping of live stock and at the same time to ensure the production of a sufficient margin of food to keep the land stocked economically. Crop drying would supply the margin.

On the other side the problem of the dung cart and feeding remained. The essence of successful modern agriculture seemed to him to lie not in revolution but in the application of the old well tried practices to modern conditions. Thus the Hosier system of dairying would seem on first sight to be a revolution but it was in fact only the combination of milking out of doors, as Thomas Hardy described in "Tess of the d'Urbervilles," and using the methods of folding sheep on the land in order to make the animals do their own dung carting. In this connection he had seen outdoor milking without the folding, as is done in East Prussia by gathering the cattle into an enclosure before milking—a scheme almost identical in its aspects to the Hosier scheme : while in central France he had seen cattle folded and moved from day to day on the mountain side without the milking. It might well be that some combination of fixed yards for winter and movable dairies for summer would solve the difficulties of heavy ground. The old arable folded flock with all its attendant labour had probably gone for ever as he himself had found to his cost. On the other hand some development of the sheep folding system of quickly erected folds on lines of common sense, with breeds that could both fold and graze might still be a possibility. Similarly the organisation of arable pig farming was absolutely in its infancy as was also the question of making chickens spread their own droppings and keep healthy by moving continually over fresh ground.

He made no excuse for postulating these problems or for reiterating the necessity for these improvements to be accompanied by the assurance of national stability because without it the farmer may not be able to induce his bankers to give him credit to carry out the improvements.

In conclusion Lord Lymington said that he believed the ideal form of future agriculture would be one which any of our farming ancestors with sound instinct and adapted intelligence could return to carry out and even improve.

MR. C. S. ORWIN (Oxford).—I have listened to the papers and speeches to-day with the greatest interest. The work in progress at Rothamsted which Sir John Russell has described, is providing just that information which is needed for the guidance of those who are trying to maintain soil fertility by agents less expensive than farmyard manure. Mr. Newman and Mr. Nevile have given us their valuable experience of machinery technique, and Professor Watson has addressed himself to the very practical question of the extent to which the everyday mixed farmer can take advantage of this technique without involving himself in revolutionary changes of practice.

Professor Watson's paper is timely because the best-known examples of power farming, whether on plough land or on grass, demonstrate an entirely new farming technique, evolved by its exponents for exploiting to the full the means to lower production costs afforded by mechanical equipment. Thus, we know of Mr. Nevile's and Mr. Dudley's new crop husbandry, and Mr. Hosier's milk production system is even better known. But it will be a long time before any considerable proportion of farmers in the corn-growing counties, or in the dairying districts of the south, will be so completely mechanized.

But while doing what we can for this predominant class of the farming community, we must remember that in districts and on types of farming to which the new power machines are applicable, all attempts to graft the new methods on the old should be regarded only as an expedient, as the first step in the evolution of power farming. Sir John Russell indicated quite clearly that he is thinking of new technique for farming by mechanical power, in his work at Rothamsted, and Mr. Nevile had clearly the same idea in his mind when he told us that " the four-course rotation is done."

Now what I want to suggest is that side by side with the study of engineering problems and of soil physics problems, there is need for the study of the farm management problem under mechanical labour systems. All our existing farming systems are based upon the speed and the capacity of the horse ; all the operations of the farm are controlled by the fact that the horse can only walk at the rate of 2½ miles an hour and work for an eight-hour day. At the same time, he must be fed and cared for, work or play. And so was evolved the magnificent farm routine which has served the farmer so well for countless generations, by which the work of the farm was spread evenly over the seasons, involving the cultivation of crops of all sorts, each in due season—some for man and some for stock to be returned to the land as dung. Only by such a system was it possible to give economical employment to the only available form of power—the horse.

But surely mechanical power, independent of rest, independent of daylight, costing nothing when idle, and making the farmer for the first time virtually independent of the weather, must have altered the whole approach to economic farming. The farmer for the first time can take short cuts, and freed from these restrictive influences, can set himself to evolve a power-farming technique adapted to the new conditions, which will mark an advance in economic production from the land as great as that which must have marked the substitution of bullock and horse teams for manual labour.

The technical problems of farm organisation under the new conditions call for the fullest consideration if the maximum advantage is to be derived, and it is along this line that the work of the pioneers we have heard to-day is so valuable. Some of them have confined their efforts to the economical production of particular commodities—corn crops or milk—but though intense specialisation of this kind is possible, and probably profitable, it must not be thought that mechanized farming necessitates concentration on one commodity if the best results are to be secured. Others here to-day, Lord Lymington and Mr. A. H. Brown produce both animal and crop products, and much more work is needed before we shall know what are the greatest possibilities and what are the limitations of the application of power to farming.

Mr. A. H. Brown (Hayling Island) emphasised the fact that corn growers were faced with two alternatives, either they must give up corn growing, or reduce the cost of production. There were, he pointed out, several ways of reducing costs. One was to increase the yield by better cultivation and more intelligent manuring, then to mechanize all operations whenever such a procedure was practicable. Mechanization would entail reduction in both horse and man labour. It should also mean the cutting and grubbing up of hedges, so that fields could be thrown together for the purpose of large area cultivation.

With fewer men, it would be possible to pay higher wages, and higher wages would attract a more intelligent type of worker on the land. It was certain that the cutting of wages would not produce this.

The Rothamsted experiments he continued had proved to him that corn could be grown continuously with the use of artificials only. He had applied that knowledge to his own farm with considerable success.

In 1913 he set aside a field to be cropped without the use of dung or sheep. In 1914 the yield of spring oats from the field amounted to 2½ sacks. The following year it was bare fallowed: but from then onwards it has been cropped every year with a succession of crops—no particular rotation being followed. The yield of corn averaged 6 quarters of wheat and 8 to 10 quarters of oats. Three white straw crops have frequently been taken in succession and sometimes four or five.

It was at the present time, continued Mr. Brown, an easy matter to keep land clean. This could be accomplished by the intelligent use of tractors after harvest. Clean land was, of course, the basis of good farming and good crops. Badly or half-cultivated land would not grow good crops even if one were foolish enough to manure it heavily.

He maintained that the small farmer would be wise to leave corn growing to the large farmer and the foreigner and to concentrate his capital and capabilities on something that would give a larger turnover. He did not see how 50 acres of corn could be made to pay any money. Neither did he believe that cereals would rise or be fixed at some fancy price. Even if corn were stabilised it was very doubtful if the Nation would long continue to foster the inefficient corn grower, for that was what a subsidised price would mean. Even with corn at 40s. a quarter, a 5-quarter yield only gives £10 for the corn. How many small farmers can get their costs below £10 an acre, and how many can obtain an average of 5 quarters? But he believed the large farmer could get his costs nearer £5 than £10 and also average 5 quarters per acre.

Mr. Brown summed up his remarks as follows:

(1) That any land that is worth keeping under the plough can be made to grow good crops indefinitely with the use of artificial fertilisers alone, provided it is given good cultivation and intelligent manuring.

(2) That such a method is more economic than using either the dung cart or the sheepfold. For many years he had believed that arable sheepfolding and yard fattening bullocks merely for the purpose of obtaining manure was economically wrong. If, as in his case, dung was produced as a bye-product, then it had to be used.

(3) Land farmed in the way he had indicated would definitely increase in fertility.

Mr. E. D. Wolton (Norfolk).—All the previous speakers have dealt with mechanization as applied to large areas of land and I think 300 acres of arable was the smallest extent mentioned. They have also spoken in detail about the combine harvester and in short considered the subject on a large scale. But this aspect is not of much use to the average small farmer farming about 150 acres and in my talk I should like to dwell on mechanization as applied to the small farmer who cannot possibly mechanize on the combine harvester scale. Unfortunately the terms " mechanization " and " combine harvester " seem to have become inseparable and when one is mentioned the other invariably follows, with the result that the small farmer is inclined to think that mechanization is totally unattainable for him. He sees photographs of tractors ploughing six furrows at a time, drawing three drills and harrowing in one day more than the acreage of his whole farm, and all these new developments depress him. I hope to prove that the small farmer having about 150 acres, half of which is arable, need not fear this new development and that mechanizing his farm should be of equal advantage to him as to the large scale farmer. In the days of horses the small farmer could not really compete with the large farmer in the production of corn but somehow he managed to get a living and I contend that if he mechanizes he can regain his former relative position.

It is said by many farmers that owing to small fields it is impossible to mechanize on small farms. I should like to point out that the low-powered tractor will always take two furrows as against one furrow with horses and therefore with a tractor there is only half the turning. Also the fact that however little way a horse ploughs, whenever it turns round it always has a breather, and be as strict as you like, it is impossible to prevent the horses and men ceasing work for a time. A tractor, however, never has a rest and these reasons prove that a tractor ploughing a small field is certainly not at a disadvantage compared with horses.

It seems obvious to me that the small farmer who relies on horses for power is doomed. He may hang on by reducing his standard of living and working from dawn to dark, but this course does not allow him to live as life should be lived, as he has become a slave. The small farmer who refuses to make his conditions of work worse than a labourer goes bankrupt. Horse power cannot possibly compete with a tractor which :

(1) Does the work of at least three men and six horses.

(2) Ploughs all day—and night if necessary—by working in reliefs, and so takes full advantage of favourable weather.

(3) Always has ample power available.

Also the whole urge of the horse plough-man is to go home. He and his horses get tired walking all day and the latter are even more eager to get home than he is. When he gets home he has to pump them water, feed and groom them and so naturally he wants to get home early and so is reluctant to take advantage of favourable weather and keep on with his work. The tractor man, however, sits all day and so does not get so tired and as soon as he finishes his work, he can go straight home.

Tractors have flexibility and adaptability to circumstances but

https://doi.org/10.23637/ERADOC-1-207

horses usually work the same hours whether the weather is good or bad.

Another advantage of a tractor over horses is that if a tractor breaks a part it is usually available in a few days. If a horse breaks a leg, it is a complete loss.

In addition to these great advantages there are others less obvious but by no means less important, which should be taken into account. The mere fact that the tractor man rides and a horseman walks, gives the former a superiority complex and this combined with the fact that riding is much less tiring than walking spurs him on to greater efforts and there is never any trouble about working overtime. This superiority complex is an asset which cannot be valued high enough.

Then there is the psychological factor that the tractor engine is always turning over at a fast rhythm and this does subconsciously impel the tractor man to get on as fast as he can so as to be in harmony with the tractor. The tractor urges its driver on but the influence of horses is to retard the ploughman. Speed to a tractor man is a joy—to the horseman an effort.

I do not consider that small farmers should attempt to copy the large scale methods of mechanization but should adapt their present systems of farming to the needs of the tractor. Thus it would be advisable to drill as much corn as possible in the autumn before the land gets wet and while the tractor can get about easily. They must alter their whole conception of the tractor as supplementary to horses, and realise that the tractor must be the main source of power, with a horse or pair of horses to supplement it. The tractor must be first and horses last. By adapting—not discarding—their present systems of farming to the tractor small farmers can keep to their traditional mixed farming and there would be no revolutionary changes, with their consequent problems to solve, such as farming without stock, difficulties of keeping up fertility, disposing of straw, etc.

To illustrate the lines on which I suggest small farmers should proceed I will relate how I have adapted mechanization to suit my own farm which consists of 150 acres of heavy land, half of which is arable. My Fordson tractor—

(1) Ploughs all the land including opening and shutting furrows.
(2) Cultivates and also breaks down for seeding all land.
*(3) Drills and rolls (or harrows) in one operation.
(4) Rolls and harrows all land in one operation.
(5) Draws the mower and so cuts all hay.
*(6) Cocks the hay.
*(7) Loads all hay by pulling wagon and hay loader.
*(8) Draws all full loads at haysel and harvest to hard road.
(9) Draws the binder and so cuts all corn.
(10) Grinds my corn.
*(11) In conjunction with a neighbour's does my mole draining.

**Notes*

(3) When drilling, a man sits on a platform fastened to the back of the drill, it would be impossible for him to keep up with the tractor if he had to walk.

(6) The cocking machine draws the hay from the rows into large high heaps and these just need putting into shape by hand.

(7) All my wagons have frameworks fitted by means of bolts all the way round, at the sides these come out one foot beyond the usual edge. The front and back frameworks are joined on to the usual ladders at an almost perpendicular angle. From the tops of the front and back frameworks, stays come down to the centre of the bottom of the side frameworks and this leaves a space in the middle of the sides of the wagon unframed, this is for unloading hay, loading and unloading sheaves of corn. The effect of the frameworks is to make the capacity of the wagon very large and to obviate all necessity of careful loading and to avoid waste of time roping. The hay loader is fastened behind the wagon and the tractor draws them both along the row. The hay comes up at such a rate that it is all the two men in the wagon can do to get rid of it. (I do not use a sweep as my meadows are too small). In harvest the frameworks save one man, as one man in the wagon can deal with two men pitching when he does not have to mind how he loads. When there are only two men they can both pitch and make a good load without either of them getting in.

(8) If there are hills or if there is no time to spare the tractor can bring the full wagons to the hard road very much quicker than horses. There is an attachment which is fastened in a few seconds to the shafts and then to the tractor so there is no time wasted changing shafts.

(11) Where the drains were to go, I ploughed as deep as I could Then my neighbour came with his tractor and mole drainer and by fastening both tractors to the drainer and by driving them tandem we were able to drain to a total depth of 18-20 inches. He did two days at my farm and I did two days at his and it cost us nothing except fuel as we did not charge each other.

I find that every spring I can clean half my foul land in time to drill it with barley. The other half I grow with winter tares or another cleaning crop and pull the land about after the crop has been taken off thus through mechanizing I avoid all long fallows and take a crop off each field each year and so benefit in cash.

Now that I have stated what my tractor does I think everyone must be convinced that there is ample work for a tractor on a small farm.

Not only should the small farmer benefit from mechanization but he has the following advantages over the large mechanized farmer:

(1) If his tractor breaks down he normally has two horse sand these can be used and so he has an alternative source of power.

(2) His system is flexible and can be adapted to new conditions easier than the purely mechanized farm. All his eggs are not in the basket of corn production and live stock will always have a place. If oil rose to a prohibitive price he could easily change back to horses.

To sum up:

(1) By mechanizing, the small farmer can put himself in the same relative position to the large farmer as he used to hold before mechanization.

(2) He must mechanize on his own lines and not necessarily copy large scale mechanization.

(3) Mechanization extends the size of farm which can be run as a family farm.

(4) Tractor power is progress and if adapted by the small farmer to his needs should be his salvation.

For these reasons I consider that mechanization should be of at least equal advantages to the small farmer as to the big and that the small farmer has nothing to fear, but everything to gain, from mechanization.

Mr. R. Dudley (Andover).—I am in entire agreement with all that Mr. Nevile has said with reference to the use of the combine harvester. On the question of windrowing grain I have tried this and given it up in favour of direct combining "once over, all over" *provided one has an efficient dryer*. My reason for this is that in this climate the risk of a heavy crop of grain (for we must grow heavy crops if they are to pay) lying in the windrow is too great to be taken. The grain has in any case to be treated at the farm and it can therefore be winnowed to take out the thistle heads, poppy heads and broken pieces of weed and straw before being passed through the dryer.

On the general question of cereal production it has now been proved that we can produce, by the aid of modern machinery grain of the highest quality almost independent of the weather hitherto our greatest bugbear. Machinery too can enormously add to the production of feeding stuffs for live stock.

We have then on our own doorstep the very market that our manufacturers are searching the world for in vain, a market of at least £200 millions, if the Government would only see that measures are taken whereby the wholesale prices are made remunerative. This would not necessarily mean that the retail prices should rise.

It must never be forgotten that almost every item of cost on a farm is fixed by Parliament, wages, tithe and even a tax on the most efficient fuel we have for cultivation on the mechanized farm, viz., petrol.

It would therefore seem but elementary justice that competition should be placed on a fair basis by making the foreign product bear the cash equivalent of exactly the same burden as is inflicted by the State on the home product, no more but no less.

SIR R. GREIG (Dept. of Agriculture, Scotland).—In my view the development of the internal combustion engine along with the possible utilisation of electricity is opening up a new era in the technique of agriculture. Great advances have been made in the last ten years in the application of the motor tractor to cultivation, and some other operations on the farm. Several cultivations can now be carried out in one operation, and there is no reason to believe that further adjustments between power and its application will not be made. The first obvious use of power traction is in the sphere of large-scale cultivation. But the possibilities are far from ending there. A motor can be any size, placed in any position, and worked under almost any circumstances. It is a matter of time and experiment to ascertain its further uses. The main point is that while steam engines made a radical change in the methods of the industrialist and but little change to the farmer, the internal combustion engine now enables the farmer greatly to increase the power of a man and the workability of the land.

The new possibilities involve a new technique or new methods or adjustments in agricultural practice. The new methods will be profitable if they reduce costs and increase output. This may involve reduction of labour if large scale mechanization is the sole outcome. But is the story ended here ? That depends upon the ability of the present-day farmer to increase the output of a man's labour not only in large scale operations but in so-called intensive and mixed farming. By far the larger part of the country is unsuitable for large grain farms. It is on this larger part that new methods must be tried. If they succeed through the application of power units, not fewer but more men may be employed. Heavy clay land now all in grass may be brought into profitable mixed farming. The turnip and mangold may be out of date and other forage crops capable of machine handling may take their place. In any event it is not necessary to assume that the mechanization of agriculture means only large scale cultivations.

Since the war the productive efficiency of a man has greatly increased in most industries. In some industries this efficiency has increased 100 per cent. In agriculture it is understood to have increased about 50 per cent., but if by the use of power and changed methods the efficiency of a farm worker can be doubled, there is a possibility of employing more labourers, for the following reasons.

The British home market is practically unlimited. If by the use of power units and a new technique the cost of production of a gallon of milk, a ton of silage, a cwt. of beef, mutton or pork, can be reduced, then it will be possible greatly to develop much of the land now in grass or on the margin of cultivation. Such development will be likely to maintain, if not to increase, employment on the land. Progress in that direction will depend upon (a) further experiments upon the use of power units from 100 horse power downwards, (b) the invention of power machines for drilling and harvesting or collecting forage crops, (c) the advantages of the artificial drying of forage crops, and (d) the possibility of making new adjustments as between crop and stock and the development of a technique for the purpose.

Dr. B. A. Keen (Rothamsted).—Mr. Newman's paper was naturally mainly confined to the engineering aspects of mechanization, and I am glad that some of the subsequent speakers directed their remarks towards the practical field problems connected with the use of mechanized implements and farm machinery.

There is a tendency to regard the problem as primarily that of the replacement of the horse by some suitable form of mechanical or electric power; so far as haulage, elevating machines, and the general class of barn machinery are concerned this is true, but in the matter of cultivation implements, it is only part of the problem, and probably not the most important part. For this class the real problems are the following: (1) whether the essential agricultural features of the present horse-drawn implements (i.e., the design of those portions entering the soil) are still substantially correct for power-drawn models, and (2) whether some radical departure in design should be made, such as rotary cultivation or, alternatively, the combination, on one frame, of implements which are at present used separately.

The final answers to these questions cannot be expected at once, because they hinge on first answering the question of exactly what effect on the soil is produced by our cultivation implements. We know, in a general way, that the object is to produce a tilth, and we can recognise a tilth when we see it. We recognise, further, that one part of the action of an implement is to break down, or to refine, the large lumps of soil into smaller ones. But that is about as far as our empirical knowledge goes. We cannot predict, for example, what will be the effect on the final tilth of the initial operation if ploughing is performed at a speed of 4 m.p.h. instead of the 2-2½ m.p.h. customary with the horse-drawn implement. The study of cultivation implements with special reference to the result of their work on the soil, and on the subsequent growth of the crop has therefore been carried on at Rothamsted for some years past.

We have shown by dynamometer measurements of soil resistance that, for any given implement, the force necessary to draw it through the soil is but little affected by the speed of travel. In the case of ploughing, an increase of speed from 2½ to 4 m.p.h. resulted in only

7 per cent. increase in draught. This is a very important result. In the design of any implement, the agricultural engineer has to balance as far as possible a number of conflicting requirements and, but for the result just mentioned, he would certainly have assumed that the draught increased greatly with increased speed, with the result that he would have decided on a smaller and more robustly built implement than the circumstances warranted. The conclusion is of general application ; it means that the development of the tractor and of power-drawn implements should aim at the highest possible speed consistent with mechanical reliability. The need for increased speed of work, on both climatic and economic grounds, is now generally recognised, and it is fortunate that one possible objection to it has been shown to be without real foundation.

Our field experiments at Rothamsted have shown the predominant effect of season on tilth in medium heavy soil. The conventional range of horse implements is unable to do more than mitigate the ill effect of bad weather. Thus in one series of experiments in which a bad season for cultivation followed a good one, the most efficient implement produced a worse tilth in the bad season than the least efficient implement in the good season. It is not far wrong to say that if the autumn and winter climate has been suitable, then almost any tool will produce a good tilth. This conclusion stresses the need for a close study of the possible improvements in cultivation methods, since on the average we can only count on about one favourable season in three.

Mechanization does offer such possibilities : greater power and speed enable us to work the soil more vigorously and in particular to do several operations at once. Our experiments have shown that there is a greater latitude in the times and methods of cultivating medium heavy soils than is generally supposed. In particular, the stages of producing a tilth can frequently be telescoped into one operation by hitching implements in tandem, or in series, behind the tractor. Cultivators, harrows, and rollers have been used by us in this way with success, and with no detriment whatever to the yield as compared with the orthodox methods. There is much scope here for implement designers to produce compact and easily assembled units for these combined operations, thus avoiding the present clumsy necessity of hitching existing implements in a long train behind the tractor.

The range of disc implements merits greater use with tractors. They are unequalled in their ability to " force " a tilth in difficult conditions although, in passing, it may be mentioned that our experiments have shown the ridging or bouting plough to be surprisingly effective in this direction. Disc implements admittedly leave the work in a rough condition, and there is some prejudice on this count, especially against the so-called disc-plough. But the preference for the smooth, well set-up, and nearly unbroken furrow is gradually fading ; provided the land is left well ridged and with plenty of large lumps (and the disc plough can easily be set to

https://doi.org/10.23637/ERADOC-1-207

secure this) the danger of beating down under bad weather to an unkindly condition is no greater than in the case of the smooth furrow slice and, in addition, the subsequent cultivations are much easier and more immediately effective.

On the question of entirely new departures in implements suitable for power, rotary cultivation has received much attention. It is now well established in market-garden and orchard work, and attempts are being made to introduce it into ordinary arable farming, with more or less success. The primary claim is that it will produce a seed-bed in one operation and thus appreciably reduce the costs of these operations as at present carried out. We have made extensive experiments at Rothamsted over a number of years on the production of spring seed-beds, on autumn-ploughed land, using rotary cultivation in comparison with horse and tractor implements. In every case the rotary-tilled seed-bed gave better and quicker seed germination, and superior early growth of the plant. But, also in every case, the early advantage was completely lost as growth proceeded, until at harvest the rotary-tilled plots were no better, and often worse, than the others. This effect was traced to the form of tilth produced by rotary cultivation. It is not a finer tilth than that secured by the usual methods, but is much looser or "fluffy." Subsequently, it settles appreciably, to the detriment of the well-developed root system which the earlier and looser tilth had encouraged. Another contributory factor is the heavier growth of weeds on the rotary cultivated plots. The thorough mixing of the soil produced by rotary cultivation also implies that the weed seeds are distributed throughout the full depth of cultivation ; this factor results in the survival and active growth of many weeds that would otherwise have been destroyed or rendered innocuous in the normal cultivation operations.

These two factors—the ultimate loss of the initial superiority in early growth, and the trouble with weeds—are serious disadvantages, but the difficulty of avoiding them is probably not insuperable. They constitute, of course, the main obstacle in the replacement of traditional cultivation tools and methods by a single machine producing a seed-bed in one operation. A second obstacle is the problem of using rotary cultivation instead of the plough for autumn and winter work. Our experiments indicate that a rotary cultivator with a ridging attachment behind it may solve this problem. If this is borne out by further trials, and if the two difficulties already mentioned connected with its use for spring work can be overcome, then there will be full justification for the claim that the extensive range of cultivation implements and the detailed and numerous operations at present required to produce a tilth, can be replaced by the much simpler equipment and the greatly reduced number of operations characterising rotary cultivation. Then the saving in implements and labour, and the ability to make full use of suitable weather in a difficult season, would certainly make rotary cultivation one of the triumphs of mechanized farming.

SUMMARY OF THE AGRICULTURAL PROBLEMS INVOLVED

By H. G. MILLER

Rothamsted Experimental Station

THE most important point in this Conference for the ordinary farmer is the question of the effect of new mechanical developments, new knowledge and new ideas on his actual farming. Few farms in this country will escape these influences, but their extent will depend on the geographical and geological position of the farm, the layout of its land, and on the character of the farmer himself.

I. Complete Mechanization

The most extreme form of power-farming, mechanized corn-growing, is most likely to establish itself in parts of the South-East and South of England. Quite possibly this may prove the best means of utilising this area. The chief factor that determined corn-growing areas in the past was the climate and it is still the chief factor governing the general suitability—and therefore, essentially, the economic soundness—of various crops in any district. Political action here or elsewhere may, of course, profoundly modify the logical effect of climate. Also, there is no point in producing crops most suitable to the local climate if there is already world over-production of these. The newly issued Report of the Imperial Economic Committee on " The Wheat Situation " makes one more doubtful than ever of the desirability of corn growing—or at least wheat growing—in this country at present. Yet if new methods will enable us to produce corn as economically as any other country, mechanized and specialised corn-growing ought to have a place in some districts when world conditions become more settled.

An occasional break in continuous corn growing seems essential both for weed control and the maintenance of fertility. A fallow every third year may be necessary, either bare, or supplemented by the ploughing in of a green manuring crop like mustard or rape. In other cases less frequent breaks may suffice. Alternative crops may be preferable to fallows, such as clover for hay or seed, with or without a bastard fallow, sugar beet, if it should confound its critics by becoming a permanent feature of South-Eastern agriculture, silage or green crops for feeding to stock.

https://doi.org/10.23637/ERADOC-1-207

This country, it is frequently claimed, has the best climate for grass production next to New Zealand. Grassland enthusiasts do not except the South-Eastern Counties from this generalisation. Temporary grassland is often advocated for inclusion in farming systems in that area. Our own experience at Rothamsted favours this idea. Yet can we honestly claim grass to be the most suitable crop in so comparatively dry a region ? In two out of the last four years the yield of grassland measured in Starch Equivalent and Protein Equivalent units has been relatively low. For several weeks in each year growth ceased, at a time when required most for stock. Temporary grassland in the South-East has been advocated for two chief reasons—economic necessity and the maintenance of fertility. In the old days when each of the crops in the 4-course rotation was economically sound, grassland was of only minor importance in the South-East (apart from soil unsuitable for arable farming). If mechanization is to re-establish arable farming on an economic basis, what room will there be for a crop like grass which is so dependent on frequent showers ? The maintenance of fertility by means of this crop may of course justify its inclusion. The possible losses on grassland in dry seasons may be less than the cost of maintaining fertility with the dung-cart. Fundamental information is badly wanted on the relative productivity in Starch Equivalent units, over a period of years, of the various crops in each of a number of different districts. Official statistics cannot supply this information for they do not give the yields of one of the most important crops, grass for grazing, or of those of considerable potential importance, grass and other green crops cut green for drying, while still young.

In the South-East then there are considerable possibilities of further rural depopulation on account of mechanization. Sugar beet does not offer much hope of counteracting this tendency, as is clearly shown in that admirable book of Lord Astor's and Dr. Murray's "Land and Life." Market garden crops on small farms, or on selected areas of large farms, are much more hopeful. Live stock dependent on grassland, whether temporary or permanent, occupy a doubtful position. Formerly their importance was slight in most parts of the South-East. Much grassland has lately been established on soils which, under the climatic conditions in this area, are not really suitable. An expanding milk market, or good beef and mutton prices, may keep them in grass and encourage temporary leys even if arable farming revives, specially while farmers are so short of capital for the purchase of the implements necessary for mechanization. Stock independent of grassland, such as pigs and poultry, however, offer more scope for reducing the risks of rural depopulation in the South-East.

II. Partial Mechanization

A new agricultural idea is often in grave danger of being brought into disrepute by over-emphasis. It is to be hoped that mechanization and all the new ideas accompanying it will escape this fate. Throughout most of the country the ideas and practices of complete mechanization must be modified to suit the particular conditions of different farms and districts. The various speakers at this Conference have given a very comprehensive survey of new facts, ideas, practices and possibilities. It is now up to the individual farmers to go through these carefully and pick out the material applicable to his own case.

The maintenance of fertility has been fully dealt with, but the question of dung has been left in a rather unsatisfactory position. The cost of handling it is easily exaggerated, because it is a job which can be done at leisure. Old farming systems were admirably balanced in their labour requirements throughout the year. Now in our zeal for labour economy we may end by advocating a new system in which, during two or three of the winter months there is no work left to be done. Dung-carting is a very suitable operation for this period and requires no big staff.

I do not suggest that we should necessarily aim at a system giving a high production of dung but rather that we should not regard as a liability the dung produced by necessity, where stock are kept indoors—as certain classes to a large extent always will be. The need for dung has been, and is being, reduced. But the idea of using the animal as the dung cart while possessing many advantages does not eliminate carting. Concentrates must be carted to the field and in some cases straw and hay. This is a particular disadvantage where no odd horse is kept, and in spells of bad weather. I am very doubtful of the practical possibility of outwintering fattening cattle. Under the best conditions it is difficult to make a profit in this department. Frequent and regular feeding and the stockman's constant watchfulness are essential. Outside, the cattle would miss these, and, in addition, would require additional food to supply the energy for greater movement.

The mechanical handling of dung deserves more attention from implement makers and would go far towards answering criticisms as to the costliness of present methods.

The position of live stock has been emphasised already. How best to fit live stock husbandry in with the new developments of mechanization is a most important problem. Professor Watson's suggestions certainly seem practicable. They present a strong argument, ably supported by Mr. Nevile and Mr. Wolton, for leaving the sizes of fields as at present. If a push-combine is developed, the headland difficulty at harvest will disappear ; and the introduction of smaller machines will make it possible to use combines on farms at present using only two binders.

Professor Watson's cropping scheme is a modification of a common Scottish rotation, where sheep occupy a prominent part in the utilisation of the temporary ley. One of the most interesting questions in live stock husbandry to-day is whether sheep can maintain their present place in combination with temporary leys, or whether there will be a big swing over in favour of dairying. A strong point in favour of sheep maintaining their position in lowland farming is that, unlike Denmark, we have a great reservoir of sheep in our hill and mountain districts.

But whatever form of live stock is best adapted to combination with new cropping systems, the question of winter keep inevitably arises. Root growing is the *bête noire* of many farmers and nearly all agricultural lecturers. The root acreage has certainly dropped heavily in this country, especially where conditions of either soil, climate or labour were unsuitable. But in several districts, roots are as largely grown and as important a crop as ever they were. New methods open up the possibility of actually increasing the root acreage. Roots are on the borderland of being economic in many cases ; if the labour bill could be reduced, they might once again be grown on a sound basis. If we regard them as a crop for clean land—where the cleaning has been done on another occasion by the tractor—are they not more promising ? The extension of piece-work rates in paying labour would also help.

Professor Watson's suggestion concerning kale is timely, especially for most of the southern part of the country where the day of the mangold and swede appears to be over ; in fact, if the weak points of kale can be overcome, it may even invade the strongholds of orthodox root growing. Much information is still wanted about kale, for example :

(1) The difference in yield, if any, between thinned, bunched and unthinned crops.
(2) The difference in feeding value between thinned and unthinned, at different stages of the plants life and at different times in the year.
(3) The relative advantages of wide and narrow rows regarding yield, ease of cultivation and weed control.
(4) The loss in feeding value and bulk occasioned by frost and means of minimising this.
(5) The possibilities of replacing roots with kale in late March and April.

There is strong justification for the suggestion that we should use mechanization to the full in this country as a means of increasing our supply of feeding-stuffs for live stock, thereby reducing our bill for imports, and maintain the rural population by intensive stock farming and market gardening. One suggestion for increasing this supply is to cut and dry young green stuff. Lord Lymington thinks there are more possibilities in growing corn for this purpose than in harvesting it. I have found no figures to support his assertion that corn when cut green and fairly young, yield more pounds per acre of Starch Equivalent than when carried through to harvest. While it is true that with modern methods both crops would have to go through a drier, the cost of drying the green stuff would be much the greater. Further, the second growth from the corn that had been cut green would be very poor and straggly. It would really need to be ploughed up and a fresh crop sown involving more expense for cultivation and seed, and running the very serious risk of failure through drought. Under-sowing is a possible means of overcoming this difficulty. Catch-cropping is far too risky except in rainy districts. There may well be a big future for the preservation of young green stuff by drying, but scarcely along those lines.

The potentialities of mechanization are so great that we cannot expect them to be fully discovered and exploited immediately in all the different farming systems in this country. Farmers must feel their way towards new methods. The " inevitability of gradualness " applies to farming practice as well as to social progress. It may be wrong to patch old ideas with new methods but it is safest to begin the change-over in that fashion. Electricity is a factor which can do much by saving labour and time, in modernising old methods and ideas. Careful consideration is necessary before saying a new idea is better than an old idea modernised.

https://doi.org/10.23637/ERADOC-1-207

GIBBS & BAMFORTH, LTD.,
ST. ALBANS.