The Growing of Lucerne

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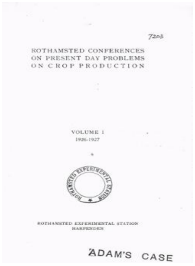

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ROTHAMSTED CONFERENCES ON PRESENT DAY PROBLEMS ON CROP PRODUCTION

VOLUME 1

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ROTHAMSTED EXPERIMENTAL STATION
HARPENDEN

ROTHAMSTED CONFERENCES

I. THE GROWING OF LUCERNE

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ROTHAMSTED CONFERENCES, No. 1

This booklet is the first of a series giving the papers and discussions at the conferences held at Rothamsted on the leading present-day problems in crop production. The papers are written by well-known experts on the subjects, and discussed by some of the best practical farmers in the country. The information thus collected is of such interest and is so difficult to obtain elsewhere that it has been decided to publish it for the benefit of farmers, agricultural experts and students.

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THE GROWING OF LUCERNE

BEING THE REPORT OF A CONFERENCE HELD AT ROTHAMSTED ON JANUARY 27TH 1926 UNDER THE CHAIRMANSHIP OF

SIR JOHN RUSSELL, F.R.S.
Director of the Rothamsted Experimental Station

With Contributions by

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INTRODUCTION

THE papers included in this volume were read at Conferences called at the Rothamsted Experimental Station to discuss crop production problems of great practical importance to British farmers. For each subject the first paper outlines the problem, later papers show how it has been dealt with: some of these are by practical farmers who are successfully overcoming the difficulties, others are by scientific investigators showing the results of experiments designed to elucidate the principles concerned.

This combination of Practice with Science evoked on all occasions an interesting discussion, the points of which were summarised by an expert for inclusion in the printed volume. The papers were all written to be printed and they were fully corrected before appearing in this volume: they contain detailed accounts by practical farmers and by scientific workers of some of the most important aspects of present day British crop production.

E. J. RUSSELL.

ROTHAMSTED EXPERIMENTAL STATION,
HARPENDEN.
May, 1930.

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PAPERS

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THE SPREAD OF LUCERNE GROWING

By Sir JOHN RUSSELL

Director of the Rothamsted Experimental Station.

Some eighteen months ago Lord Bledisloe and I decided to take Arthur Young's advice to the farmer of his day "to view some farms in well-cultivated countries and to introduce himself to the conversation of his intelligent brethren, from whom he would be sure to learn something useful." Accordingly we travelled across Canada and the United States to see what farmers were doing and to discuss their problems with the experts on the spot. Wherever we went we found farmers and Experiment Stations busily investigating the lucerne crop—alfalfa it is called there. The developments were remarkable. When I first went to Canada in 1909 the area under lucerne was less than in England; we then had some 58,000 acres. In 1923 Canada had 391,000 acres, while ours had not increased. The United States in 1899 grew 2,000,000 acres of lucerne; in 1924 there were 10,500,000 acres: their acreage has doubled every ten years since 1899. Ours has not: it has certainly increased since the beginning of the century from 48,000 acres to 65,000 acres in 1924, but the increase does not compare with that across the Atlantic.

Inquiry into the reason for the popularity of the crop showed that it had proved of exceptional value wherever farm labour is dear, or where, as in Denmark, production is being intensified. Both these conditions can be found in Britain. The crop has long been grown in certain places; it came into this country with clover some three hundred years ago: clover spread all over the kingdom, while lucerne remained confined to the Continental highway of Kent, Essex and a few parts of the Eastern counties.

One reason for the spread of clover is that the organism living in its root nodules, on which it depends for successful growth, is native to this country and flourishes in our soils, while the organism associated with lucerne is not a native and does not generally occur in the soil, so that the crop starts handicapped if not foredoomed to failure. Those farmers in the Eastern counties who grow lucerne find it invaluable; it will stand for four or five years, giving three cuts a year, two of which can be made into hay, while the third is fed green: and finally when the crop is ploughed out the land is left so rich in nitrogenous organic matter—the costliest of all fertilisers—that it will give a succession of heavy crops with little extra help.

The trouble about the nodule organisms has been satisfactorily overcome by Mr H. G. Thornton of the Bacteriological Department

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here. He has grown the organisms in quantity and has shown how to add them to the soil where they are lacking. The method had to be based on careful laboratory studies, but the testing on the field scale has been done on a number of farms in different parts of the country, an expensive matter which, however, has been rendered possible by the generous support of the Royal Agricultural Society. The method of inoculation is described fully by Mr Thornton in a later paper. The results show that inoculation brings about an increase in crop—sometimes, indeed, makes all the difference between success and failure—and it improves the feeding value of the crop, so that 1 ton of hay from inoculated lucerne is worth as much as 25 or 30 cwt. of lucerne hay grown without inoculation.

The crop has peculiarities and troubles. It is somewhat delicate when young; of all crops it is then the most sensitive to competition: indeed at the end of its first year it often looks so bad that farmers are tempted to plough it up; yet if they would but leave it the second season shows a great difference. The secret of success is to keep down weeds in the first year.

It will not tolerate water-logged soils, nor will it stand a very wet autumn. But it does not need, as some assert, abundance of lime in the soil; only freedom from acidity. The best manures are basic slag and potash. The land must be clean, for weeds are difficult to eliminate once the crop is sown.

The varieties under test are Provence, Grimm and Hungarian. The time of sowing is on some farms the end of April, on others July; probably this latter is the better date, as it allows time for late cultivations to kill weeds.

No cover crop is necessary in the Eastern counties, but in the wetter West it seems desirable to help in keeping down weeds. Where a cover crop is grown inoculation seems especially necessary.

The seed bed should be firm, the tilth fine, and the seed should not be sown too deeply, not more than 1 in. below the surface. The best rate of seeding is not clearly known; it varies on different farms from 15 to 30 lb. per acre. The width between the drills is determined by the weed difficulty; in the Eastern counties it is desirable to set them wide enough for the horse hoe to pass—say, 10 in. apart; in the West it may be better to broadcast the seed on clean land so as to have the ground covered, especially where rain prevents the killing of weeds by the hoe. Some farmers fall between two stools and sow in narrow drills that cannot easily be hoed; this is a mistake. All experience shows that the plant once well established can be heavily harrowed and cultivated and so kept clean.

Conversation with farmers who grow lucerne shows apparently wide differences in practice. These can often be explained as ways of dealing with the weed problem in the first year. But the crop

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is so new that much still remains to be learned, and one purpose of this Conference is to obtain from practical growers accounts of their difficulties, so that the experimental programme can be made to give better and more useful knowledge.

LUCERNE INOCULATION TRIALS

By H. G. THORNTON, B.A.

Rothamsted Experimental Station

The experiments upon which I wish to open a discussion concern the treatment of lucerne seed with cultures of *Bacillus radicicola*, the micro-organism that produces nodules upon the roots of leguminous plants. It has long been known that the organisms living in the nodules are beneficial to the crop, owing to the fact that they build up from the free nitrogen of the atmosphere compounds that the plant is able to utilise.

As long ago as the nineties Nobbe and Hiltner developed the idea of artificially supplying leguminous crops with the nodule bacteria. The early trials of legume seed inoculation gave very variable and unsatisfactory results, but with the extension of our knowledge of the principles concerned there has been greater success in recent years, and the inoculation of certain crops has become a recognised practice in many parts of the world, especially in America and Scandinavia. The failure of the process in the early years of its use seems to have been due partly to faulty technique and partly to its application to unsuitable crops.

In recent years the methods of storing the bacteria in the laboratory have been improved, so that they can now be kept without loss of vitality, and the media upon which they are issued to the farmer have been modified so that, on the new media now used, fresh cultures can be prepared at very short notice.

The exact method used to apply the bacteria to the seed appears also to be of importance, as their activity in the soil may be affected thereby. Recent work in the laboratory has shown that the bacteria pass through a definite cycle of changing forms in the soil. During certain stages in their life-cycle they are actively motile and, in this condition, are able to migrate through the soil. When inoculated seed is sown the bacteria have to pass through the soil to reach the various parts of the root system where the nodules are produced. The timely appearance of the motile forms in the soil is thus of vital importance. The nature of the fluid used to convey the bacteria to the soil influences both the time of appearance and the relative members of these motile stages. It produces a corresponding influence on the migration of the bacteria through the soil,

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example, when a suspension of the bacteria in *water* was added ıe soil it took three days before they began to spread away the point of inoculation. When a suspension in *milk* was d, the initial rest-period was reduced to forty-eight hours, while a suspension in *milk and calcium phosphate* the bacteria began ›read after twelve hours. The addition of calcium phosphate to milk thus stimulates the bacteria to migrate through the soil increases the volume of soil infected by them in a given time. the common method of inoculating seed is to wet it with a ›ension of the bacteria in skim milk. Pot experiments were efore made to see whether the addition of calcium phosphate to milk would increase the effect of inoculation. The phosphate was ıd to increase the number of nodules produced very consider- and also to improve the crop. Thus not only has laboratory erience enabled us to maintain healthier cultures of the nodule teria, but recent knowledge of its life in the soil has modified our hod of applying these to the seed.

A second cause of some of the early failures with inoculation the application of the process to unsuitable crops. It is now ›wn that the nodule-forming bacteria are divided into varieties, h of which is able to infect only one or at most a few kinds legumes. Now some of these varieties are almost universally sent in our soil. For instance the organism that produces lules on clover is found even in the tap water of this laboratory. such cases inoculation can scarcely be expected to benefit the ›p. On the other hand certain crops that have been introduced o the country do not find the correct variety of the organism in r soil unless this is in some way introduced, and it is there that ›culation is likely to be helpful. Lucerne is a crop of this kind. was introduced into England about 1630, but since that time its owth has extended very little beyond the South-Eastern counties. ithin this area it is extensively grown and usually develops dules on its roots without inoculation, showing that the soil has, the course of centuries, become infected with the lucerne nodule ganism. Attempts to grow it in the West and North of Great itain meet with very uncertain results; and while some failures re can be attributed to climate, the evidence indicates that the ›sence of the lucerne nodule organism from the soil is another ıportant factor.

We therefore decided to make a large-scale test of the value lucerne inoculation in this country. For the reasons explained it as expected that in certain areas inoculation would be beneficial, hile in other districts the presence of the bacteria in the soil ould render inoculation superfluous. It was therefore necessary › make trials at places distributed all over the country to find out there were districts where the process would be profitable.

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Experiments are now in progress at some fifty centres distributed over Great Britain. They are being carried out by agricultural colleges, farm institutes and private individuals whose ready co-operation has made the tests possible. The Royal Agricultural Society has made grants towards the cost of the work. The tests were commenced in 1924, but the very wet summer of that year resulted in the loss of some of the trials and a further series were started this year. At the present time there are thirty-one trials in progress. The majority of these were commenced too late to enable cuttings to be weighed, but in eight cases this was done, and in seven of these the inoculation was found to produce a benefit either in weight or in the nitrogen content of the crop. These results are briefly summarised in the following list showing the percentage increase due to inoculation at trials in each county named :—

Kincardineshire	10, 40, 17 per cent.	Gloucester	179 per cent.
Durham	16·8 ,,	Wilts	141 ,,
Staffordshire	2 ,,	Cornwall	31 ,,
Warwickshire	35 ,,		

In the case of the Staffordshire trial the difference in yield is insignificant, but there was an increase of 48 per cent. in the percentage of nitrogen in the hay. Since this nitrogen is mostly in the form of albuminoid it will be seen that, here also, the food value of the crop has been greatly increased by the treatment. A great difficulty in the experimental work is due to the fact that the bacteria spread from the inoculated into the uninoculated strips, so that the increase due to the treatment appears less in the trials than would have been found under field conditions. In some trials a marked benefit from the treatment has been observed, but it has not yet been possible to confirm this observation by weighings. If one plots the distribution of all the stations where inoculation has shown a benefit, it is seen that outside the South-Eastern counties twenty-two centres out of twenty-eight show a benefit. The remaining centres have in most cases been sown late in the season and may show an effect next spring. The conclusion seems justifiable that in these districts inoculation should always be adopted save on fields known to have grown good lucerne crops before. There are indeed cases where inoculation has enabled good lucerne to be grown on land that has never before successfully grown it. Within the South-Eastern counties the advantages of inoculation are still doubtful. There are three centres where a benefit has been obtained, but it is likely that a local presence or absence of the lucerne bacteria in the soil will make it impossible to predict the effects of inoculation in this area. We hope, however, to obtain more evidence from fresh centres in this area during the coming year.

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Inoculation should chiefly help us by enabling the area of successful growth to be extended. To do this, however, there are two limiting factors to be overcome: the cold winters of the North and the weeds due to wet weather in the West. It is possible that some of the Canadian or Scandinavian varieties of lucerne may be sufficiently cold-resistant to grow in the North, and this possibility is being tested. The weed problem, however, has always been paramount. There seem to be two possible ways of dealing with it. One is late sowing. In the course of our trials sowing has been carried out at times ranging from April till August, and the best and cleanest have been those sown in July, since it is then possible to clean out the majority of annual weeds before sowing. The second possibility is to use some cover crop. It is recognised that in the Eastern counties a cover crop is undesirable, but in the West one is often faced with the alternative of having an intentional cover crop or an unintentional cover of weeds. The weakening effect of a cover crop is largely due to its removing nitrogen from the young lucerne. Inoculation renders the plant more independent of soil nitrogen, so that the cover crop then does little harm in this way. For this reason our trials have shown that where a cover crop is used, inoculation is the more necessary.

I feel that this problem of weed suppression is vital in the extension of lucerne growing, and I hope it will be discussed by those more competent to do so.

SOME SCOTTISH EXPERIMENTS WITH LUCERNE

By ANDREW CUNNINGHAM, B.Sc.

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The experiments with lucerne carried out by the Edinburgh and East of Scotland College of Agriculture were begun in 1920. In that year a culture for the inoculation of lucerne was received from the United States Department of Agriculture with a request that it should be tested. An experiment to test the effect of inoculation was carried out at Seton Mains, East Lothian, on land which showed a lime requirement (Hutchinson and MacLennan's method) of 1 ton calcium carbonate per acre. The inoculation was applied to the seed. The crop was a complete failure.

An endeavour was made to ascertain whether lucerne was grown satisfactorily anywhere within the College area at this time. Three small plots were discovered—one at Pathhead, Midlothian, one at Newtown St Boswells, Roxburghshire, and one at Cupar, Fife. All

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three plots carried excellent crops. The one at Cupar had been inoculated; the other two had been neither inoculated nor limed. The plot at Pathhead yielded three good cuttings annually and had been sown five years previously. The soil from the Newtown St Boswells and Pathhead plots showed no lime requirement but contained calcium carbonate.

In 1923 a small area at Scone was used to test the effect of inoculation and liming. It was divided into four equal parts, two of which received ground limestone at the rate corresponding to the lime requirement. A culture for inoculation was obtained from the United States Department of Agriculture. It was used for inoculating half of the seed, which was drilled 4 in. between the rows. The plots were arranged to give uninoculated, unlimed; uninoculated, limed; inoculated, unlimed, and inoculated, limed areas. A good crop was cut in September 1923. Inoculation increased the crop yield from 50 to 80 per cent. and nearly doubled the percentage of nitrogen in the dry matter (see Table, p. 12). Owing to the fact that the plots were small the yields have been stated as percentages of the yield of the unlimed uninoculated plot. The plots at Scone have yielded two good cuttings each year since 1923 and the inoculation has now spread to all four plots.

In 1924 a more extensive series of experiments was planned to test the effect of inoculation and liming. The general arrangement of the plots was the same as at Scone, but the whole area at each centre consisted of $\frac{1}{4}$ acre divided into four $\frac{1}{16}$-acre plots, except at Boghall, where a total area of 1 acre was sown. The lime requirement of the soil was determined by the Hutchinson and MacLennan method, and ground limestone was applied in excess of the lime requirement to two of the plots some time before the seed was sown. All four plots also received a dressing of phosphatic and potash manures. The inoculation consisted of a mixture of cultures isolated from plants obtained from the plots at Scone and cultures from the United States Department of Agriculture. The cultures were grown on mannite agar. The growth was suspended in water and the suspension was used to water the seed for the inoculated plots. The seed used was a mixture of two parts of Provence to one of South American and one of English grown. It was drilled in April and May, 8 in. between the rows, at the rate of 30 lb. per acre. Precautions were taken to prevent transfer of inoculation in sowing, and a path 3 ft. wide was left between the inoculated and uninoculated plots in order to reduce the risk of spread of inoculation.

Considerable difficulty in establishing the crop was experienced in most of these experiments. The crop failed in five of the eight centres. At the remaining three centres—Camptoun and Ballencrieff in East Lothian, and Boghall in Midlothian—the experiments

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TABLE

	Sown	Cut	Lime Requirement	Weight of Dried Crop				Nitrogen in Dry Matter per cent.			
				Limed		Unlimed		Limed		Unlimed	
				Inoc.	Uninoc.	Inoc.	Uninoc.	Inoc.	Uninoc.	Inoc.	Uninoc.
				Per cent.	Per cent.	Per cent.	Per cent.				
Scone, Perthshire . . .	May 1923	Sept. 1923	0·1 ton $CaCO_3$ per acre	152	104	184	100	2·76	1·82	3·05	1·63
Ballencrieff, East Lothian . .	April 1924	July 1925	1·2 ton $CaCO_3$ per acre	254	100	...	...	2·34	1·47	...	...
		Aug. 1925		127	40	...	...				
				cwt. lb.	cwt. lb.	cwt. lb.	cwt. lb.				
Boghall, Midlothian . .	May 1924	July 1925	0·5 ton $CaCO_3$ per acre	30 109	17 44	32 43	20 18	2·73	1·22	2·47	1·11
		Oct. 1925		22 23	...*	16 103	...*	4·53	3·43	4·27	2·36
Kildinny, Perthshire . . .	June 1925	Sept. 1925	3·2 tons $CaCO_3$ per acre	35 46	24†	11 76	4 96	3·47	1·84	...	...

* Insufficient to weigh. † Estimated.

were more successful. The plots at Camptoun gave a fair yield the first season. Unfortunately, however, they had to be ploughed up at the end of the first season for reasons which had no connection with the experiment. The experiments at Ballencrieff and Boghall gave small yields the first season, but in neither case was the crop sufficiently large to weigh.

The crop obtained in these experiments in 1925 has, as a rule, been fed green to animals. In order to secure a figure for the weight of hay a weighed sample has been taken in the field and air-dried in the laboratory. Owing to the fact that it has been found to be practically impossible to prevent inoculation from spreading to the uninoculated plots it has been difficult to obtain values which accurately represent the effect of inoculation. Generally speaking, it has been necessary to cut and weigh the crop on selected representative areas and to calculate the yield from the data so obtained. The results, however, do not truly represent the effect of inoculation, because the crop on the uninoculated areas has consisted almost entirely of weeds.

The procedure outlined sometimes necessitated the weighing of the crop from comparatively small areas, as for example at Ballencrieff. In this case, therefore, the results have been stated as percentages of the yield of the limed uninoculated plot. It should be mentioned, however, that the crop on the inoculated limed plot in this case, as well as at Scone, was decidedly superior to that on the corresponding plot at Boghall, which yielded about 30 cwt. per acre. Inoculation produced a marked effect on the yield and also on the percentage of nitrogen. The second cutting was taken about four weeks after the first, with a view to allowing of the possibility of obtaining a third cutting. This expectation, however, was not realised. The Boghall results also show the beneficial effects of inoculation on yield and percentage of nitrogen. A fair total yield has been secured. Although the second cutting gave a smaller weight than the first, it contained a higher percentage of nitrogen and a higher actual weight of nitrogen per acre than the first.

The high proportion of failures in the experiments started in 1924 was attributed to:

(1) Too early sowing and the cold wet season. As a result the crop grew slowly and was difficult to keep free from weeds.

(2) Late application of lime. The lime was applied generally less than one month before sowing, and probably therefore had not sufficient time to exert fully its beneficial effects. Thus soils with a higher lime requirement than 1·2 ton failed to produce a crop.

(3) Inadequate cleaning of the land in certain cases.

In 1925 experiments were begun at four new centres. In those cases the lime was applied three to five months before sowing. The

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seed was sown in June, and before sowing the land was harrowed from time to time to encourage weed seeds to germinate. The soil was then thoroughly cleaned and cultivated just before the crop was sown. The seed used consisted entirely of the Provence variety. Otherwise the arrangement of the experiments was the same as in 1924.

So far as one can judge, the crop at three of the four centres appears to have established itself. A cutting was obtained at all three centres at the end of the first season. In one case (at Kildinny) the yield of the inoculated limed plot was 35 cwt. per acre, which is highly satisfactory. At the other two centres the yield of the corresponding plot was under 1 ton. These results are more promising than those secured in 1924 and lend some support to the view that the modifications introduced in 1925 have had a beneficial effect. At the fourth centre the failure is attributed to the fact that the soil was too heavy for this crop.

Our experience with lucerne therefore indicates that on soils adequately provided with lime a satisfactory crop can often be grown without inoculation. On soils with a distinct lime requirement the beneficial effects of liming and inoculation have been demonstrated and promising yields have been obtained in certain cases. Late sowing with thorough preliminary cleaning and cultivation of the land seems to be of value in establishing the crop. From the practical standpoint the greatest drawback appears to be the uncertainty of obtaining a satisfactory yield the first season. The work will, therefore, be continued with a view to trying to overcome this difficulty. An attempt will also be made to obtain further data on the yield obtainable on soils adequately provided with lime.

LUCERNE FOR THE DAIRY FARM

By J. MACKINTOSH, N.D.A., N.D.D.
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The value of lucerne as a forage crop has been recognised and the crop largely grown throughout the southern countries of Europe for many centuries. It appears to have been introduced into England in the seventeenth century, and its cultivation on suitable soils slowly spread throughout the South-Eastern counties. Marshall, in his *Rural Economy of the Southern Counties*, published in 1798, mentions that the cropping practice of the district of Maidstone and also of the Isle of Thanet is distinguished from that of other parts of England by the frequency with which lucerne is grown in small fields, "not, however, standing in rows with hoen intervals, as in other countries,

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but growing at random, as sainfoin, clover and other cultivated herbage."

The main purpose for which lucerne was then grown was for cutting and feeding green to horses in the stable during the summer, and it was only after the nineteenth century was well advanced that this crop came to be recognised as specially suitable for the feeding of dairy cows. Appreciation of its value for this purpose was doubtless stimulated by the reports published in *The Journal of the Royal Agricultural Society* and elsewhere of its popularity on the dairy farms in France and other countries. In 1885, however, the area under lucerne in England and Wales was only about 14,000 acres; during the ten-year period 1894 to 1904 the area rose to 55,700 acres, in 1922 to 57,900 acres, and in 1925 to over 60,000 acres.

The early advocates of lucerne growing laid special stress on the drought-resisting powers of this crop and on the number of cuts which could be obtained in one season, and little was said about its nutritive value beyond the general statement that horses and other stock throve well on it.

At the present time those who press the claims of lucerne as a forage plant and who desire to see a greatly increased acreage grown in this country, especially on dairy farms, lay stress on its valuable qualities in three different aspects: firstly, its value as food for cows compared with other similar crops; secondly, its rapid growth after the first year and power of giving three cuts annually for four to seven years or even longer, independently of the weather conditions; and thirdly, its importance as a nitrogen-collecting crop, thus enriching the soil during its growth, and making the application of dung almost unnecessary for several years after.

From the point of view of providing food for stock, lucerne can be made into hay, cut green as a soiling crop, or cut, chaffed and made into silage. When made into hay the food value of the product naturally varies considerably according to the degree of maturity of the crop when cut and the methods employed in making the hay. The leaves are the most digestible and nutritious part of the plant; hence great care should be taken to preserve the leafage as much as possible. The chemical analysis of lucerne hay as given in *Rations for Live Stock*, published by the Ministry of Agriculture, shows that when the crop is cut for hay before it is in flower the percentage of digestible crude protein is higher than in any other kind of hay, with the exception of that made from tares cut at the same stage of growth, and also higher than in any home-grown cereal grain. If the lucerne is in full flower at the time of cutting, the percentage of digestible protein is somewhat reduced, but is still higher than in any other common hay, and equal to any of the cereal grains except wheat.

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A hay of the above quality is, therefore, a valuable source of protein for growing stock and for dairy cows, and a good supply will lessen appreciably the need for purchased concentrates—for example, 14 lb. lucerne hay (cut when the crop is in full flower) and 30 to 40 lb. mangels require to be supplemented only by 1 to 2 lb. crushed oats or other cereal to provide a ration for maintenance and the first gallon of milk, whereas 14 lb. average quality meadow hay and 30 to 40 lb. mangels require to be supplemented by 1 lb. decorticated ground-nut cake and 1 lb. crushed oats to provide a ration of similar protein content.

Lucerne is even more valuable as a soiling crop on a dairy farm, because, after a first cut has been taken and made into hay, as a rule two other cuts can be obtained, one towards the end of July, when the pastures often are bare, and another in September. A moderate crop of lucerne will give at each cut about 5 tons green forage per acre, and if 35 to 40 lb. per head daily be allowed, 1 acre will suffice for twenty-eight cows for ten days in July and again in September; or in other words, 1 acre will provide about 40 lb. green fodder daily for seven cows for almost three months during the driest part of the year. Further, in a moist season, when there is more grass and less need for forage crops, any surplus can be made into hay or silage, according to the weather conditions at the time the crop is ready to cut. It must also be remembered that lucerne hay is richer in lime and phosphates than any other dry fodder, and green lucerne is richer in these constituents than any other succulent food, with the exception of sugar-beet tops. It is probably better that cows should receive their mineral matter through a crop than in the form of mineral supplements to the ration.

The duration of a lucerne ley, once it is properly established, may be anything from four to seven years, and the possession of 5 to 10 acres of a crop which provides three cuts of good hay or forage or silage annually for this length of time should be invaluable on many dairy farms where it is at present unknown. Results up to this standard cannot be obtained without care in the preparation of the seed bed, cleaning before and after sowing, suitable manuring, and some surface cultivation year by year; but operations of this nature *have* to be carried out annually to a greater extent for almost every other crop, so that over the duration of a good ley the cultural operations are materially less than where the land is under a rotation of crops. There is, however, still need for a considerable amount of experimental work to find out the best methods of stimulating the plant during the first year of its growth, and the safest and most efficient after-treatment to prevent the ley becoming overrun by weeds.

The effect of a lucerne crop in increasing the fertility of the

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soil on which it is grown, by increasing the nitrogen content thereof, adds to its value, not only to the dairy farmer, but to all who wish to increase the fertility of their farms. A crop with the persistency and productivity of lucerne would be of great agricultural value even although it diminished the all-round fertility of the soil on which it grew. We should therefore appreciate it all the more when the most expensive manurial ingredient—nitrogen—is greatly increased in amount and the soil improved in physical condition by its growth.

The above summary of the many virtues of lucerne, most of which have been known in this country for at least fifty years, almost inevitably gives rise to the question, "Why is it not grown to a much greater extent than at present?" Perhaps the commonest answer to this question is that it is by no means easy to ensure a good plant. There have been many failures, and the local history of one failure is likely to be quite as widely known as that of a success.

The discussion on this subject which is to follow may therefore be more helpful if I add a short statement on the experience which we have had in attempting to grow lucerne successfully on the farm of the National Institute for Research in Dairying.

In 1922 a field of 8 acres was sown with lucerne in August. The field was clean but not in good heart, and before drilling different manurial dressings were applied to a number of plots. No definite results were obtained on any of these plots, and throughout the field as a whole the lucerne was slow in establishing itself. In the following year there was a very thin plant of lucerne and annual weeds grew freely. The crop, such as it was, was cut out for hay in July, and the yield was estimated at from 5 to 7 cwt. per acre. This return was very disappointing, and in the autumn the question arose as to whether the field should be ploughed up, or the lucerne left for another year. The latter course was decided on, and in the autumn of 1923 the whole field was cultivated both ways to a depth of 2 to 3 in. and afterwards harrowed. This treatment led to a great improvement, and in 1924 a useful crop of hay and a second cut of green forage was obtained. The autumn of 1924 was too wet to permit of cultivation, but in March 1925 another vigorous cultivation and harrowing was given, and a still better crop was obtained than in the previous year. On one side of the field, where only straggling plants and spaces bare of lucerne were to be found in the autumn of 1924, lucerne sprang up thickly and covered the ground effectually. A good crop of hay was obtained in May, a cut of green fodder for cows in July and August, and another in September and early October.

Had the lucerne ley been ploughed up at the end of the first year, as was advised by some observers, no return would have been

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obtained for the preceding twelve months, but by surface cultivation the plant was apparently stimulated, and a good return, considering the nature of the soil, has been obtained during the past two years, with every prospect of obtaining a similar return for one or two years more.

Our experience of the severe competition which the lucerne met with from weeds during the first year of its growth led us in 1924 to lay down a series of plots in order to get further information on the effect of surface cultivation after sowing. For this experiment an area of about 4 acres was selected which was considered to have been well cleaned and reasonably free from weeds. On 24th June the seed was sown; on four sets of plots it was broadcasted and on the other four it was drilled. On 12th July, one month after sowing, specimen plants were dug up to find, if possible, how far the root had penetrated. It was found that the roots had penetrated to a depth of at least 8 in. in this short period of time. A few weeks later, owing to a strong growth of weeds which had unexpectedly appeared, the whole area was run over with a mower and the produce carted away.

Immediately afterwards one-third of each drilled plot was hand-hoed, one-third harrowed three times, and one-third untouched. Of the broadcast plot one-third was left untouched and two-thirds harrowed three times. During the spring and summer of 1925 the competition from weeds became more severe and the plant as a whole was disappointing. Those plots which had been hand-hoed showed a better and stronger growth of lucerne than any of the others, while those which were harrowed were superior to those which had received no treatment. There was no evidence that the harrowing of the plant within two months of sowing had done any harm, and it appears probable that the weed competition may be materially lessened by surface cultivation at this early stage.

In this experiment and in the 8-acre field previously referred to there was no failure of seed. A good plant of lucerne was obtained in the early stages, and the outstanding difficulty was that of keeping down the growth of weeds and of obtaining a reasonable yield of lucerne during the first harvest year. It must be recognised that lucerne does not develop quickly, nor attain its maximum until the second or third year, but nevertheless the produce during the first year should surely be equal to a moderate crop of hay.

Both the fields referred to above received about 20 cwt. ground lime per acre previous to sowing the lucerne, but no inoculation treatment was carried out. On an adjacent field in the farm the previous occupier had grown a useful crop of lucerne, and it was therefore considered that in our attempt to grow this crop we should, in the first instance, proceed independently of inoculation in any form.

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On many occasions I have discussed with dairy farmers the advisability of growing a small area of lucerne, and frequently I have been met with the complaint that when they had tried it they had been able at first to get a satisfactory plant, but were very disappointed with the first year's growth. Apparently, therefore, before the acreage under lucerne can be materially increased it is essential to find out by what methods of cultivation competition from weeds can be kept down, and how a fair crop can be obtained during the first year. It may be that inoculation will aid materially in this respect, and a stronger growth in the early stages will thereby hinder weed growth. Dairy farmers and others will value greatly any assistance or advice which will increase the return during the first year of the plant's growth.

LUCERNE GROWING IN HIGH AND WET DISTRICTS

By R. D. WILLIAMS, M.Sc.

Welsh Plant Breeding Station, Aberystwyth

Lucerne is grown only to a very small extent in the Western counties. In Wales, for example, it is almost entirely confined to a small area in South Glamorgan. During recent years several half-hearted attempts have been made to introduce it into other districts, but without much success. Why is lucerne, which is generally acknowledged to be the best fodder crop in the world both as regards productivity and feeding value when grown under suitable conditions, not grown to a larger extent in districts such as Wales, which are devoted mainly to stock-rearing?

There are several reasons for this: the most important are the absence of lime in the soil, high rainfall, and the fact that the growing of lucerne is often undertaken without the full appreciation of the special requirements of the crop. Thus, for example, it is not an uncommon practice to sow lucerne with a seeds mixture under oats or barley, regardless of the soil and weather conditions of the district. It has been repeatedly shown by various experiments conducted in different counties that under conditions prevailing in Wales lucerne is nearly always a complete failure when sown in this way. In an experiment conducted at Aberystwyth, in 1922-1923, lucerne was sown in a very simple mixture consisting of 5 lb. of tall oat grass, 7½ lb. of an early red clover and 15 lb. of Provence lucerne per acre. The soil was deficient in lime and phosphates. The phosphates were made good by the application of slag at the rate of 6 cwt. per acre. Though the seeds germinated quite well, lucerne

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was unable to make headway, apparently owing to the severe competition from the tall oat grass and red clover, and when cut for hay in 1923 the plants were very small—their average height being only 5 in.—and sickly in appearance. The percentage composition of the hay was as follows :—

	Per cent.
Red clover	48·7
Tall oat grass	44·5
Unsown grasses and weeds	6·4
Lucerne	0·4

In other words, the lucerne produced only 20 lb. of hay per acre —that is, the weight of hay was only 5 lb. more than the weight of seeds sown. That this was largely due to competition was shown by the results of another experiment set up in the same field on exactly similar soil, in which the lucerne had been sown alone in wide drills and therefore not in competition with other species. About 15 cwt. of hay (first cut) was obtained from the experiment.

Lucerne is far more sensitive to competition, especially during its early stages of growth, than any other forage crop grown in this country. Consequently, except perhaps on soil which is particularly suitable, it should always be sown alone and in drills, so that it can be kept free from weeds right from the very start until the crop is firmly established. The best stands at Aberystwyth have been obtained by sowing in drills about 12 in. apart. When sown at this distance the crop helps to keep the land clean by filling up the drills during the summer when the growth is too tall to send the hoes through.

Considerable care should be exercised in selecting fields for growing lucerne. It is merely a waste of time, labour and seeds to attempt to grow the crop on very exposed fields or on shallow, heavy or badly drained soils. The fields should be fairly well sheltered, preferably with a southern aspect. The soil should be fairly deep and well drained. It is a sound practice in wet districts to sow the crop after roots, as the land is then fairly clean and in good heart.

Most of the soils in the extreme west are very deficient in lime, the lime requirements being often over 2 tons per acre. The absence of lime is due partly to the fact that the soils are in the main derived from non-calcareous rocks and partly to the leaching action of the rain. The average annual rainfall in most districts in Wales is well over 40 in.—that is, practically twice as much rain as in the east of England. Lucerne, more than any other crop, except possibly sainfoin, requires a high proportion of lime in the soil, and before it can be grown with success in wet districts the soils must be heavily limed.

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The results of two experiments carried out at Aberystwyth are interesting in that they show the kind of crops often obtained when lucerne is sown on soils very deficient in lime. These were red clover trials in which a few plots of Provence lucerne—some in drills and others broadcasted—were included for comparison. The lucerne was sown at 30 lb. per acre, and red clover at an average rate of 15 lb. The lucerne germinated quite as well as the red clover, but the plants remained very small and stunted throughout the seeding year and the first harvest year, and by the second year they had died back completely. The average yields of green fodder per acre of lucerne and Montgomery red clover during the first two years were:

Experiment I

	1923	1924
Montgomery . .	158 cwt.	59 cwt.
Lucerne . . .	6½ „	...

Experiment II

	1923	1924
Montgomery . .	165 cwt.	61 cwt.
Lucerne . . .	7 „	...

In most cases where lucerne is grown for the first time the soil should be inoculated. The simplest method of doing this is to inoculate the seeds of the first crop with an artificial culture, then if the crop has been properly inoculated to use the soil from this field to inoculate the other fields. But if the soil is very deficient in lime, inoculation has practically no effect. This was shown to be the case in an experiment laid down in 1920. In this experiment a number of plots were sown with inoculated and uninoculated seeds of Provence lucerne on soil very deficient in lime. There was practically no difference between crops given the two treatments, both giving equally poor results.

A similar experiment was started last year in which inoculated and uninoculated seeds were sown on both limed and unlimed plots. Though it is rather early to draw any definite conclusions from this experiment, even now it is quite clear that the limed plots —both the inoculated and uninoculated—are better than the plots which received no lime. Of the limed plots the inoculated seemed last autumn to have a much more healthy appearance than the uninoculated plots.

On the inoculated plots, more especially on those which had been limed, the roots have already a large number of nodules, while not a single nodule could be found on the roots of the plants growing on the plots which had not been inoculated.

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Most of our soils are also lacking in phosphates. Lucerne in common with other leguminous crops if they are to be grown successfully must be supplied with phosphates. On soils very deficient in phosphates the best time of applying this manure is just before sowing, so as to give the seedlings a good start.

It is often asserted that lucerne cannot be grown profitably in districts with high rainfall. On the contrary, excellent crops of lucerne, lasting for several years, have been grown at Aberystwyth and other centres in Wales, and there is no reason why it should not be grown with equal success in other wet districts, provided the soil is well supplied with lime and phosphates, the seeds inoculated and sown in drills on well-drained sheltered fields, and the crops kept free of weeds, especially during the first year.

There is no doubt that the final take depends to quite a large extent on the time of sowing. If sown too early—say, in late March or early April—a large percentage of the seedlings may be killed off by late frost; and if the sowing is delayed until too late, winter will set in before the plants are firmly established. In an experiment on the time of sowing lucerne, conducted at Aberystwyth in 1925, seeds were sown in replicated drill plots every two weeks from 30th March to 7th August, the same number of viable seeds being sown in each case. The number of seedlings on small representative areas of each plot were counted from time to time. The results given below show the average numbers expressed as percentages of the number of viable seeds sown present on 7th September in the case of the first four sowings. The results of the later sowings are not shown, as unfortunately they are not comparable with those given by the early sowings, owing to the fact that germination was badly effected by the severe drought which occurred during June and July.

	Times of Sowing			
	30th March	*14th April*	*28th April*	*12th May*
Percentage No. of established plants on 7th September	19·0	12·7	49·3	43·0

As seen from these results the plots sown in late April and mid-May gave much better stands than those sown earlier.

Our knowledge concerning the behaviour of the different varieties of lucerne under different conditions is rather limited. The results of the few small-scale trials conducted at Aberystwyth suggest that Grimm and Canadian Variegated are more suitable for wet districts than Provence and other *sativa* varieties, not because they are necessarily more productive, but because they give heavier crops during midsummer—that is, from late June to August, the only period when it is usually possible to make hay in wet districts. There is

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also a certain amount of evidence which seems to indicate that the hybrid varieties are also able to withstand pasture conditions better than the common varieties.

As a plant breeder I am naturally more interested in the possibilities of breeding lucerne to suit different conditions than in the purely agronomic aspect of the work.

Like nearly all cross-fertile species, every variety of lucerne consists of a large number of distinct types. Many of these types show very wide differences in certain economic characters. In Provence lucerne, for instance, it is possible to select plants which start growth two to three weeks earlier in the spring than others; also plants which are able to give three to four cuts a year, others only two. Again, some plants assume the winter habit much earlier than others. They also differ in frost resistance, leafiness, seed production and many other important characters. Unlike some of the other cross-fertile species, lucerne is fairly self-fertile, if artificially self-pollinated. For example 76 per cent. of the lucerne plants which were self-pollinated by me in 1925 produced a certain amount of seed. If the plants were pure and bred true to type it would be a comparatively simple matter to breed improved strains. Unfortunately the problem is far more complicated than this, as nearly every lucerne plant is a product of a cross between two unlike plants, and will therefore segregate out in the next and subsequent generations into a large number of different types, even when self-fertilised. It is possible, however, to secure a certain degree of purity by self-fertilising the plants and their progeny for several generations. During this process the undesirable characters are being eliminated. When the necessary degree of purity is reached, the next step is to group together a number of pure lines showing the desired characters and allow these plants to intercross freely: this is necessary in order to recover the vigour which has been lost during the process of pure lining. By adopting some such method it will no doubt be possible to breed new strains of lucerne which might be more suitable to our conditions than any of the existing varieties. It must be remembered that most of the breeding work so far conducted with lucerne in America and elsewhere has been with a view to obtaining types with increased resistance to frost and to drought. For Welsh and West Country situations resistance to wet and more or less water-logged conditions is the first essential, and thus it is possible that strains with shallower, more fibrous and more branching root systems may be more suitable than those with the normal deep-growing top roots, and this is one of the points under consideration in connection with our breeding work.

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THE DISCUSSION

Lord Bledisloe, Parliamentary Secretary to the Ministry of Agriculture, speaking in discussion, said that he wished to record his very hearty approval of the conferences as a most useful part of the work of Rothamsted. Also he was delighted to observe the partnership between the Royal Agricultural Society and Rothamsted which was found in the work on lucerne inoculation.

He considered that lucerne is one of the most valuable crops in the world on stock farms. It is found as an outstanding crop not only in Canada and America but in most great agricultural countries.

The conditions of high cost of labour and need for intensive cultivation predicated by Sir John Russell are present with us to-day.

In the immediate future an intensification of cultivation on the existing arable area is more probable than any extension of it, and no crop is more suited to assist this development than is lucerne, which is a potent fertilising agent.

On his own land, in Gloucestershire, he had failed for fifteen years to grow lucerne, but since inoculating his seed he has been able to produce excellent crops of it, sown in the Scandinavian manner under a mixed cover crop of barley and oats.

In confirmation of Mr Thornton's allusion Mr Gardener of the Herts Agricultural Institute said that the good effects of inoculation on lucerne sown under a cover crop of barley at Oaklands were very remarkable, and far greater than those seen on the same field where the lucerne was sown without a cover crop. This being so, he was encouraged to question the policy of sowing the seed without cover, which involves the missing of a crop in the year of seeding.

The experience of three farmers in Somersetshire was adduced by Mr Hay, Principal of the Cannington Farm Institute. One man who had grown the crop for twenty years regarded it, when properly managed, as the most valuable food on the farm. He said that it can follow any crop in the rotation provided the land is clean. All three growers were emphatic in maintaining that broadcasting is the best method of sowing.

In the matter of pre-treatment, one farmer insisted that a very good tilth and firm seed bed should be obtained, and another that 3 to 4 cwt. per acre of superphosphate should be used. The grower with the longest experience recommended the use of a seed rate of 20 lb. per acre, and that the cover crop, if used, should be a very thin seeding of barley to be cut green before flowering. All three farmers used English-grown seed of unstated origin.

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When the crop is well established all count on cutting it twice in the season and on using the last growth to feed green to cows. Lucerne hay is found to be difficult to make and to heat easily in the stack. Difficulties arising from this characteristic are accentuated by the fact that the crop must not be moved much in the field for fear of loss of valuable leafage. With adequate care the crop is expected to last from six to ten years, but the growers consider that a very wet autumn will kill it out.

Mr G. P. Miln of Messrs Gartons Ltd. mentioned that trials with sundry varieties of lucerne had been carried out by his firm during the past few years at three different centres. Two strains of English-grown seed were used with Provence and Grimm.

The English seed had produced the best results, followed by the Provence, with the Grimm a good fourth. English lucerne seed is to be saved this year from the main crops and not from the later cuts.

Mr Dampier Whetham expressed the gratification of the Research Committee of the R.A.S.E. on the success of the inoculation experiments carried out by Rothamsted. He considered that new research work is required in matters of cultivation and in the production and testing of varieties. The extension of the area of lucerne presents yet another facet of the great liming problem, for over many districts where lucerne has not commonly been grown chalk-getting and lime-burning have died out. He hoped that with the spread of the crop would come the extension of such schemes for chalk-grinding as that promoted by Lord Leicester in Norfolk.

Mr Stewart of the Ministry of Agriculture said that several years ago he had noticed lucerne plants growing wild on a railway embankment near Elgin, and that he wished to call the attention of plant breeders to what might prove to be an unusually hardy variety. In more recent years he had seen the beneficial effects of inoculation, and at Kilmarnock had observed good results from the use of nitrate of soda to help the plant to a quick establishment. As an eyewitness he was able to confirm the striking results obtained on the lucerne plots at the Hertfordshire Institute at Oaklands last year. He considered that a good content of organic matter in the soil was often an important factor in the successful establishment of the plant.

Mr S. F. Armstrong of the National Institute of Agricultural Botany said that the Institute is carrying out trials with lucerne seed of different nationalities. At Cambridge, plots of Provence, English, Grimm, Peruvian, Kansas and Dakota strains were put down in May 1922 and are still in being. They yielded four cuts

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in 1923 and three in each subsequent year. Another trial carried out on the drill-strip method is being carried out in Hampshire, the strains involved being English (2), Grimm, Hungarian and Cape Provence.

The habit of lucerne is strictly perennial and the plant spends its first year in developing its root system, so that it can hardly be expected to produce a heavy crop in the first season.

In the normal way the plant continues to develop up to the third year before it comes to its point of maximum yield.

He found that there are two great essentials to be observed in lucerne growing: (*a*) weeds must be kept down in the first year; (*b*) the manuring must be correct.

The first of these requirements can be assisted by an early cutting of the first crop when it is about 8 in. high and before the weeds have time to seed. This will serve to check most of the annual weeds decisively.

On heavy land in Suffolk, some fifteen years ago, farmyard manure was found to be necessary in preparing for the crop. Nitrate of soda is useful only before the nodules are formed on the roots. Superphosphate and lime have been found beneficial over a wide range of soils and conditions, and on light lands sulphate of potash has been found to give excellent returns. He thought that in the east of England, where the rainfall is low and where some competition for moisture is likely to appear among plants in the field, cover crops for lucerne are less desirable than elsewhere.

Mr Shipway of Messrs Suttons Seeds said that from the commercial aspect the production of special strains of seed is discouraged by the small area of lucerne grown in this country. He had no wish to disparage any of the work in progress or to comment unfavourably on any of the papers brought before the meeting, but he thought that they could have but small appeal to the practical growers. A good deal had been said about the failure of lucerne in its first year, and he was able from past experience to adduce a reason for many of these failures. Farmers in general tend to cut the crop too early in its first year and while there is only one terminal shoot to each root crown. Where this happens the plant generally dies out; but if cutting is delayed until a second shoot is formed to augment and relieve the first one, no such dying out is found. This had been tested carefully by Messrs Suttons in their own trials and had been found to be true. In the matter of inoculation he suggested that some considerable caution is necessary before any such step is accepted as standard practice.

Dr Voelcker spoke of a considerable experience with lucerne at Woburn, where he succeeded in growing it for thirteen years without added lime. In the later years of the plots the need for

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additional potash became very clear, and the plots which did not receive it died out before the conclusion of the thirteen-year period. He thought that the crop should be drilled and not broadcast, and that it should be thoroughly cleaned from time to time. At Woburn the advantage or otherwise of a cover crop has been found to be mainly a matter of season, and on the whole the results show little difference between the two methods of growing.

From 1887 onwards a very large number of varieties were tried at Woburn, but the differences among the best were found to be small, and he has now returned to the use of Provence seed. He had followed closely the various attempts at inoculation since 1896, when the original soil inoculant, Nitragin, was produced. In 1905 he had seen something of new inoculation methods produced by Hiltner, and in America. Again in 1908 he had been deeply interested in Professor Bottomley's work at King's College. All these earlier attempts had come to some degree of failure, although the central idea seemed to be good and sound. The crucial question as far as inoculation is concerned is this: Has Rothamsted been able to develop a new technique which is capable of overcoming the difficulties which brought about the earlier failures?

Lord Clinton, the chairman of the Lawes Agricultural Trust Committee, who presided at the Conference, said that the lucerne crop is particularly important from a national point of view in that it is one which can be used profitably in such systems of intensive farming as tend to support an adequate population on the land. In his view any possible extension of the area of the crop is a matter of the greatest importance at the present time.

When closing the proceedings he said that he was very glad that the subject had evoked such candid and sometimes contrary expressions of opinion. Some people advocated the use of drills while others believed in broadcasting. There are those who think that farmyard manure or additional nitrogen is required, and those who will have none of either of them. Lime had been advanced as the most important factor in producing a good crop, whilst experience from another quarter suggested that adequate drainage is even more vital. No doubt the great variation of our agriculture and the diversity of individual experience will suffice to reconcile all these differences. It is the traditional policy of Rothamsted to push forward each inquiry with an open mind and all due caution. No crop or process is "boosted," but each is considered in the light of well-certified facts and wide experience.

The variety of opinion appearing at such conferences as the present one is particularly valuable in helping everyone concerned to keep the problem under discussion in its proper focus.

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SUMMARY OF POINTS COLLECTED AT THE CONFERENCE

By C. HEIGHAM, M.A.
Rothamsted Experimental Station

Importance of the Crop

(1) Lucerne as a crop is particularly well suited to conditions in which labour is dear, or where an addition of fertility to the soil is required to make possible an intensification of farming.

(2) It is valuable from a national point of view in that it may form part of a system of farming which will support an adequate population on the land.

(3) It is found as an outstanding crop in many of the greatest agricultural countries and is considered by many people to be the most valuable fodder crop in the world.

(4) The use of it in arable husbandry and its long duration make it possible for costs of production of meat, milk and corn to be lowered, which in face of the prevailing market prices is a vital consideration.

Area and Spread of the Crop

(5) In the United States and Canada very large extensions in the area under lucerne have appeared in recent years. In this country the lucerne acreage has increased from 48,000 acres at the beginning of the century to about 65,000 acres in 1924.

(6) Lucerne is found as a regular crop chiefly in the South-Eastern counties, to which it was first imported from the Continent about three hundred years ago.

(7) Recent work on the inoculation of seed with *Bacillus radicicola* has made it possible to extend the lucerne area north and westward from the South-Eastern counties.

Problems of Organism

(8) Lucerne requires the presence on its roots of a specific organism, without which it cannot grow successfully. This organism does not occur naturally in most of our soils as does that which is required by red clover, but it can be supplied by seed or soil inoculation.

(9) Various methods of inoculation have been tried from 1896 onwards, but difficulties arising from points of laboratory and field technique brought many of the earlier attempts to failure. The newer methods appear to be enjoying a considerable degree of success.

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(10) The presence of the required organism, whether attained by inoculation or not, can only bring full benefit to the crop when such other factors of growth as soil, drainage, manuring, seeding, variety and cultivation are suitable.

Problems of Plant

(11) Most lucerne plants are hybrids and are unreliable in breeding-on; differences exist between individuals in a single strain as wide as are the varietal differences. By the use of artificial self-pollination it is possible to produce pure lines as a basis for the production of new and specialised varieties.

(12) Differences of growth and hardiness are found in lucernes drawn from different sources, and a number of trials on a nationality of seed basis are being conducted. Certain hardy varieties are found useful in the more Northerly climates, among which Grimm and Hungarian are well liked.

(13) Lucerne is a perennial plant, and is often found to give disappointing crop results in its first season while it is engaged in developing its great root system. A search for means to stimulate the plant to more rapid growth in its early days is suggested as a useful piece of work which awaits attention.

(14) Cover crops can be used successfully if they are not too thick and if they do not compete too seriously with the lucerne for a small supply of available moisture.

Problems of Manuring

(15) The use of farmyard manure before sowing the crop has been found to be advantageous on some heavy soils, but on light lands it may cause a loosening of the soil, which is considered harmful to the young plant.

(16) Nitrate of soda has been used with advantage to stimulate the young plants in their earliest stage and before the root nodules carrying the nitrogen-collecting organism have been formed.

(17) Superphosphate has been used successfully with the crop in many places, notably on soils known to be short of phosphate.

(18) Potash salts have produced excellent results with lucerne grown on light land. At Woburn additional potash was found to be essential for the continuance of the crop over a long period of years.

Problems of Soil and Lime

(19) Lucerne will not grow well on shallow or ill-drained soil. On all soils stagnant water is one of its greatest enemies and good drainage is essential for a successful crop.

(20) The great balance of evidence favours the suggestion that lucerne requires a fair supply of lime in the soil. Many cases

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have been recorded where the presence or absence of an adequate lime supply has been the controlling factor in the production of the crop.

(21) Lucerne can be grown successfully on most types of soil which will carry other rotation crops.

Problems of Cultivation

(22) The land must be clean before the crop is sown and should be kept clean afterwards.

(23) The drilling of seed in hoeable rows is generally preferred to broadcasting, but with either practice the sowing should be very shallow (less than 1 in.).

(24) The seed bed should be firm and moist and the tilth very fine and even.

(25) When the plant is established in strong rows, 12 in. or more apart, it can be kept clean by the most drastic after-cultivation without fear of destroying the subsequent crop. Cultivators, horse-hoes, heavy harrows and skim-ploughs are commonly used with success as cleaning implements on strong crops of three years' standing.

(26) The number of cuts taken or the amount of grazing produced in any year depend largely upon the vagaries of the season, but generally two good hay cuts and a green aftermath for cutting or grazing can be relied upon. If the first cut in any year is taken before the annual weeds have formed seeds it will materially assist the cleaning of the land.

(27) The making of lucerne hay demands a special care, as it is desirable to preserve as much of the leafage as possible, and much movement in the field is to be avoided.

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WRITTEN STATEMENT OF EXPERIENCE

By CHRISTOPHER TURNOR

I HAVE grown lucerne on a considerable area of land for upwards of twenty years, and on one of my farms 25 per cent. of the total area is under this crop.

When I first began to grow lucerne I tried inoculating. I got the culture from the American Department of Agriculture. I fed and tended that culture according to directions. For three days I travelled about with a large blue bottle; it went with me wherever I went, and at specified times I put in the recommended ingredients, but I found no difference between seed which was not inoculated and that which was. I have now reason to suppose that the care and attention I bestowed upon the contents of that bottle were wasted upon dead bacteria.

The great essentials in regard to the successful growing of lucerne are that the land shall be well drained and there shall be a sufficiency of lime. Where the soil is deficient in lime I find that a dressing of 1 ton of ground lime per acre secures the desired results.

Lucerne is sown in the same manner as clover seed. It should not be sown more than 1 in. deep, and it cannot be rolled too much. Having tried a good many methods, in the main I like drilling 9 in. apart, as that permits of cleaning operations in the autumn and spring. One cannot be dogmatic about the time for sowing; this must vary according to the cleanness of the land, the season and the part of England. For some years I sowed in the first week of August. This allowed for a thorough cleaning of the land, and was successful if the succeeding winter was mild, but if the winter is cold I find that such late seeding runs the risk of having most of the plants destroyed. Generally speaking, I do not favour sowing in a covering crop. On the other hand, last year I sowed over 80 acres in a covering crop, and have an excellent plant.

Lucerne has a remarkable capacity for smothering and overcoming weeds, and I have had lucerne a year old in June which looked as if the weeds would entirely master the crop, but, after mowing, a splendid second crop came up and permanently mastered the weeds. The greatest enemy of lucerne is grass, and after the first year it is almost impossible to cultivate and horse-hoe the lucerne field too much, both in the autumn and in the spring.

From the economic point of view I believe lucerne to be one of the most valuable crops in the whole range of husbandry. It reduces the cost of production enormously. On the average I count

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on five years of effective cropping. I have cut as much as 4 tons of hay to the acre, but I do not regard it as a hay crop, but rather as a home-grown substitute for cake; in fact during my dairying operations of many years it has certainly halved the cake bill. It is therefore uneconomic to regard lucerne hay as hay, and not to use it in the reduction of a heavy cake bill. This is a mistake which many farmers make. In 1921 I went carefully into the cost of producing lucerne, and, taking the whole cost of a field five years under lucerne, I could produce lucerne hay ready for use at 30s. per ton. 1921 was a period of high prices, so that to-day it should be produced at under 30s. per ton.

Lucerne is also a crop which reduces the labour bill on a farm. The land still remains plough-land, but as the crop is in the land for five years instead of one or two years, as in the case of clover, a corresponding saving in labour is effected. Perhaps even more striking is the economic value of lucerne from the capital point of view. It stores up fertility in the soil more than any other plant. It is commonly supposed that the fertility so stored up will be available for a period of years equal to the number of years the crop has been in the field; but in one field of poor land, after five effective years of lucerne, I have taken eight consecutive crops without giving any nitrogenous manure. There is little doubt that there the lucerne, during the five years it was in the field, stored up nitrogenous substance to the value of at least 1 ton of sulphate of ammonia, or practically the selling value of the land (the land in question was poor third-rate land). After the lucerne crop was ploughed up a crop of mangolds was taken—an unusually heavy crop for the type of land—after that four white crops of barley and oats, then a crop of roots, followed by two more white crops. Last year the field gave a good crop of barley, and this year it is going into barley again. The corn crops were remarkably heavy. Oats, the fifth crop after the lucerne, threshed out at over 9 qrs. to the acre. Barley crops ranged about 6 qrs. to the acre. The area of this field was 17 acres, and during the time it was under lucerne it carried for ten weeks in the summer sixty head of cows, two bulls and eight horses, lucerne being fed green, and was practically the only food they had during that period.

I am very glad that Rothamsted is investigating lucerne growing, since I am sure it should play a much larger part in the economy of the farm over a much wider range of the country than it does at present.

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