THE IMPROVEMENT OF FOOTHILL COUNTRY

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The areas about which I wish to speak are those of the extensive farm, in general farmed at a low level of efficiency, irrespective of size, slope, or altitude, the improvement of which is dependent on the correction of some fertility problem. It is not therefore the foothill country, but a much greater area; it is not so much the *area* as the *problem* about which I wish to speak. The frontiers of grassland improvement have moved from the plains and downs to the hills and mountains, from the small paddock to the range, from the accessible to the remote, and this has been assisted by many factors, not the least of which is the aeroplane.

Only about one-third of Canterbury is so-called improved grassland and a similar position pertains in Otago. It is not so much this one-third I wish to speak about, although a considerable portion of it has similar problems, but the two-thirds of unimproved lands, a fair portion of which can be brought to high production by a study of the problems mentioned herein. The unimproved areas, which have demonstrable potential, are not all foothills, or mountains, or plains. There are numerous areas of each.

It is only in comparatively recent times that any real interest in the development of these areas has been shown or that they have been considered of importance. This is true of foothill areas and of the dry plains land areas alike.

It is perhaps surprising that the factors fundamental to the improvement of this country are very little different from those in the practices used on the so-called heavy fertile developed areas for some 30-40 years; simply, the use of fertilisers and the legume plant.

There is little doubt that impetus to practical application, however, was given by a more critical study of fertiliser and lime effects aimed at reducing the cost of improving marginal land which were high-lighted by the advent of molybdenum and more recently by the advent of sulphur.

This conference in Dunedin has some special significance in this respect, as it was from here that the importance of the fertility problems of the foothills began to take shaps. From here indeed came the first use of molybdenum, on the foothill country between Outram and Hindon. In this area development began based on the heavy use of lime and superphosphate coupled with cultivation, a critical examination of which has led to methods which have modified lime usage to an unbelievable degree, led to a critical study of phosphate responses, and eliminated cultivation as

Improvement of many of the tussock grasslands depends on introducing clovers and correcting deficiencies of the nutrients necessary for their growth. Twenty-five fold increases such as this may result in some areas. This could put the carrying capacities at some 4-5 sheep per acre instead of the 4-5 acres per sheep as at present.

being essential to clover establishment. From here, too, *emerged* a critical study of inoculation problems which may, be significant beginnings of a much greater development to come. From the northern portion of your province the importance of sulphur deficiencies emerged and it also contributed its part in the introduction of aerial oversowing and the exploitation of the winter as a suitable, albeit absurd, time to sow clover seed in a completely unprepared seed bed.

There can be no doubt that measured purely in terms of potential ability to produce, many of the unimproved areas could be highly productive. There is no doubt that this fact is not sufficiently realised. In their unimproved state much of the tussock grasslands intermingled with the browntop and danthonia country has a coverage of plants which carry somewhere between one sheep to

5 or more acres to one sheep per acre. In all these areas all the stock are underfed all the time. By the introduction of clovers and by correcting fertility, a 25-fold increase in measured production has been made on some. This would put the potential of some of these areas at 4-5 sheep per acre instead of the 4-5 acres per sheep. It may be absurd to suggest that this is so of much of the area, but it is true to say very substantial improvement in both nutritional levels (as reflected in wool weights, lamb percentages, decreased losses) and carrying capacity is possible over a large portion of it.

I would like now to give a brief review of some of the more important fertility problems of these margins as shown by officers of the Department of Agriculture over the past 5 to 10 years. It is not easy to decide on a logical order for discussion, so 1 will place them in the order in which I consider them important, an order which will give considerable room for argument. If they were discussed in order of the time their importance has been known there would be less argument and the order might be phosphate, lime (or both), molybdenum, sulphur, and inoculation. However, I prefer to discuss them thus: Sulphur, phosphate, molybdenum, lime, and inoculation.

Sulphur

To North Otago must go the credit for establishing the importance of this deficiency. This was in 1952 and by now sulphur has been shown to be of importance over a very wide area reaching from Marlborough to Southland. It is no exaggeration to say that some 10 to 15 mill-ion acres of the South Island are sulphur deficient. To establish this in so short a time is a fairly creditable performance.

I cannot hope to deal in detail with such an important deficiency, so I must confine my remarks to a bald and somewhat unqualified summary of the few things we know about this deficiency to date.

In the first instance it does not appear to be associated with soil type, soil fertility level, geographic location, altitude, or topography; nor with acid soils or clay soils. In fact, as far as the South Island is concerned, sulphur deficiency is where you find it.

It occurs on the coastal stones of North Otago, South Canterbury, and Mid-Canterbury and on the heavy coastal soils of North Otago, Canterbury, and Marlborough; and on the high-rainfall plains, terraces, and hills east of the Main Divide in Otago, Canterbury, and Marlborough.

It may be of equal importance in areas with rainfall below 20 in and on those with rainfall of over 60 in.

It occurs on soils with pH's below 5 and on those with pH's over 7.

It is prevalent on limestone soils and on the soils of greywacke gravels.

It might well be asked: What are the factors which influence this deficiency? Research to answer this question is awaited.

However, there are some very important fundamental aspects of sulphur deficiency which can be mentioned and on which some reasonable speculation can be made. The soil sulphur cycle, like that for nitrogen, may well be a function of the organic material and may well be influenced by soil organisms, by stocking rates, and by the manner in which it is possible to build and turn round the organic matter of the soil. The influences of low rainfall, of leaching, and of soil acidity are important. For instance, there are many soils of high fertility in North Otago, Central Otago, and North Canterbury which have low rainfalls and which are sulphur deficient. Frequently these do not have other accompanying fertility deficiencies but are generally low in organic matter and have a restricted means of building it up because of limits imposed by both plant and animal returns.

On the other hand, sulphur-deficient soils in the high-rainfall areas are leached, often have accompanying deficiencies of other elements, tend to be acid, and have low bacterial activity for the breakdown of organic matter.

There are many stages between these two. It is not infrequent to have soils in the high rainfall areas which have no other deficiencies which have relatively high pH's, which have low organic matter, and which are very responsive to sulphur. These are soils of recent origin. There are also soils of high organic matter in the low-rainfall groups which are deficient in sulphur.

The point I wish to make is that in any discussion on sulphur deficiency the organic cycle must be taken into account. The effect of cropping in an arable system is important in this respect. It has been shown, for instance, that cultivation will itself correct sulphur deficiency in some cases.

Thus I feel we have already arrived at two important points in our discussion on sulphur deficiency.

Once the purely mineral deficiencies (phosphorus and molybdenum) have been corrected or dismissed then

1. Where climatic conditions are favourable for high-producing permanent grasslands (in most of the 35-60 in inland foothills which are at a reasonable elevation and have high summer temperatures) full utilisation of pasture by stock to permit of nitrogen and sulphur turn-round is important.

2. That where rainfalls are low and unsuited to a purely grassland productive system, cultivation and cash cropping can be economic tools in restoring sulphur deficiency and in obtaining the maximum returns with the lowest input of fertiliser.

Although these points have been stressed on a number of occasions, I doubt if many have really considered them in relation to their farming practice.

Two interesting examples of the above systems are, firstly, the cash cropping on the sulphur-deficient downs of North Otago; and secondly, the conservation of hay and silage for full pasture utilisation on the 40 in rainfall areas of the Canterbury foothills.

So much for the organic side of the problem. Variable rainfall and different crops influence also the results obtained with different forms of sulphur.

Sulphur deficiency occurs over a wide range of soils and may he the most important deficiency on many of the marginal and unimproved soils of the South Island. Illustration shows the dense clover growth resulting from sulphur only in one of the early trials in North Otago.

In general it can be said that elemental sulphur will correct sulphur deficiency (for New Zealand this is the cheapest form). However, this form is slower acting than the various sulphates, as its availability to plants is dependent on bacterial conversion. This too is influenced by particle size; the finer the particle the quicker the availability. Gypsum (calcium sulphate) is the form in which sulphur occurs in superphosphate, and this is quickly available to the plant.

There are four aspects of the form in which sulphur is used which you should remember.

1. That for plants which grow and mature rapidly the sulphate (gypsum or superphosphate) may be necessary and that the finest particle material (flowers of sulphur) may be only partially effective and the coarser material not at all.,
2. That where pasture topdressing is concerned the most notable constituents of the pasture concerned with sulphur deficiency are the legumes, and that if these are already present, any form of sulphur is effective; but that the sulphates are quickest, fine sulphur next, and the other forms effective by time in relation to particle size.
3. That where no clovers are present it will depend on the time of application and the form of sulphur used'what the results will be, depending on whether the district and year are wet or dry. Thus gypsum can be superior to sulphur in dry districts or in years of low rainfall, whereas sulphur can be better than gypsum in wet districts or in seasons of high rainfall.
4. The effect of rainfall (and soil type) on leaching of the materials is important and on this would depend the rates and frequencies of application and these are in turn affected by management as already stated.

One other important difference with regard to the forms of sulphur is their effect on soil pH. It is well known that sulphur depresses pH and this technique of making soils acid is of importance in turf culture. Gypsum does not affect the soil in this way.

Suphur per ac.	pH	Suphur Per ac.	pH	cwt.	pH
	7.0	10 cwt.	6.2	24	4.2
2 cwt.	6.7	12 ,,	6.1	30	3.1
6 ,,	6.2	16 ,,	5.3	32	2.7
8 ,,	5.6	18 ,,	6.0	40	2.6
		20 ,,	5.3		

Rates of Application

It is certain that application rates for various areas will need to be -worked out. These are likely to vary with soil type, rainfall, and management. At present it appears that rates may vary between 20 and 60 lb of sulphur per acre and for some areas may be much higher than this.

The features we should be concerned with here are:

1. What is a reasonable economic level to give sufficient initial improvement up to the point where stock numbers and/or capital improvements (fencing, etc.) limit utilisation?

Winter oversowings using extra sulphur in the fertiliser mix have given some excellent establishments. Where sulphur deficiency is acute these mixtures can reduce the cost of improving this country as shown in the examples in the table in the text.

2. What are the residual effects of the different rates of initial dressings?
3. What will be the ultimate effects of repeated dressings, especialy of the heavy rates?
4. What are the residual effects of the various forms?

A limited amount of knowledge has been obtained on some of these points.

Answering point 4 first: (In practice it is of most importance, even if on the face of it this had not appeared so.) Gypsum, that is, superphosphate, is the form of sulphur most used in agriculture. It is the form with the least residual effect. In high-rainfall districts, on free-draining soils, in wet years, and under irrigation sulphur may be lost from application of gypsum (superphosphate) before the plant can use it. This has been shown in trials. It has been shown that for rainfalls of 20 to 25 in on a fairly retentive soil with an application of 2 cwt of superphosphate (1 cwt of gypsum approximately) the residual effect lasted for about a year. Under higher rainfalls and on free-draining soils the effect may be much less lasting.

A trial at Ashburton, on Lismore stony soil, with a rainfall of about 27 in. is of interest., It has shown 'that, on soils which have had their fertility built up over many years with repeated dressings of lime and superphosphate, after two years discontinuation of the use of superphosphate sulphur has declined to a limiting factor. (These soils are deficient in S, P, Mo, and lime in the initial stages, with P being very important).

DRY MATTER PRODUCTION (lb per acre)

	No Sulphur	Sulphur
Year 1955 ...	2,810	2,830
1956 ...	5,492	5,559
1957 ...	6,297	7,075

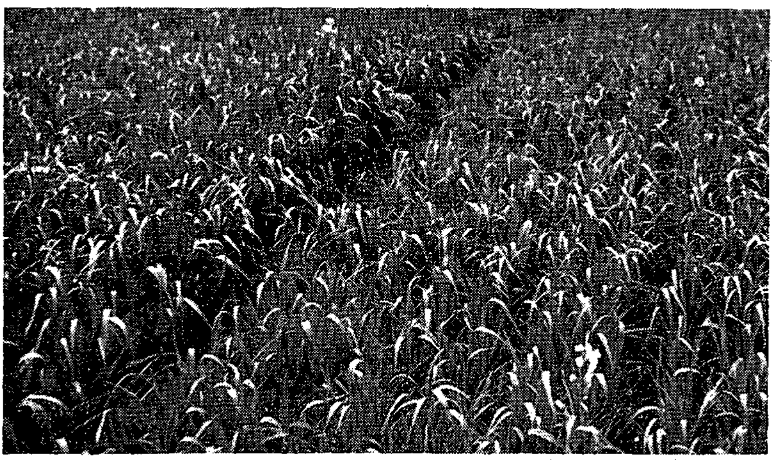
First cut on 6.10.55.

First significant increase on 4.4.57.

Four cuts after 4.4.57 all significant increases.

There is not sufficient evidence on the residual effect of sulphur at present, but with equivalent rates for that used in superphosphate it appears to have a greater residual effect. On some soils where pasture management has been good the decline does not appear rapid, as there seems little falling off in trials now in their fourth year. The manner in which sulphur will be retained will be a factor of rainfall and of organic matter build-up and decay and will therefore be of considerable variability.

Regarding point 1 above, one can instance those trials which have given sufficient evidence on which to base the recommendations which have given a widespread degree of success in practice. It would appear from these that a good average figure is somewhere between 30 and 40 lb of S (10 added by way of the gypsum



Molybdenum response on oats; North Otago. The right-hand strip received 1½ cwt of superphosphate. On the left-hand strip molybdenised superphosphate was used.

in superphosphate and 20 as sulphur). There are some areas which require more than these amounts,

No work has yet been done on the other 'aspects mentioned, but from trials now under way some information will soon become available.

Phosphorus

The next most important deficiency is *phosphorus* and more work has been done with this than with any other. This deficiency is widespread, possibly more so than that of sulphur, as it occurs on many of the areas already referred to in conjunction with sulphur deficiency and occurs in a number of other areas where sulphur deficiency has not yet been shown. This is so for Nelson, the West Coast, the Marlborough Sounds, Banks Peninsula, and no doubt in many parts of Otago and Southland.

Where the two deficiencies occur together, and this is true of millions of acres of the foothills, terraces, downs, and plains, it should be remembered that for those crops which demand phosphate, especially the *Brassicae* (rape, turnips, swedes, kale, and cbou moellier), responses to phosphates alone and not to the sulphates may be general. This is one reason (among many) why the use of phosphates in these areas has been overstressed in the past.

Responses as mentioned are well illustrated by a number of trials in South Canterbury.

We must now consider that we have a range of deficiencies to deal with; from those which need S and no P to those which need P and no S. In the intermediate ratios of these there are some 'variable reactions brought about by the relative requirement of the plant we grow and the 'cultivation of the soil concerned. Thus 'on the one soil we may in future be recommending phosphate only for some crops (*Brassicae*), sulphur only for pastures, and no fertiliser at all for other crops (wheat).

Phosphate is not readily leached from soils, and as on most of the soils where sulphur deficiencies also occur. it is not being readily fixed, it appears that, a build-up of phosphate not accompanied by a build-up of readily available sulphur may occur.

Molybdenum

The possibilities of this deficiency were early recognised in Otago so I need say little about it. 'However, each year further areas of molybdenum-deficient country are being located. This is a most variable deficiency and seems to occur as a mosaic on many soils. In general, but not always, molybdenum deficiency is associated with the major deficiencies of sulphur and phosphate or with both, It is no doubt widespread, occurring in many parts of Nelson, Marlborough, North and South Canterbury, Mid-Canterbury, Banks Peninsula, North and South Otago, the Otago Peninsula, and in Southland. It affects all crops. It has been shown to be quite important in some areas where lime has been used as the main method for improvement and the light lands of the Canterbury Plains are no exception in this respect, where a large number of trials on unimproved sites are now showing big responses.

Molybdenum is cheap, it is easy to apply, and it can be used at any time. It can be sown with the' seed, with fertiliser, or sprayed.

Rates of application have tended to be low, but advice on this matter should be sought, as this is one element excess of which can cause nutritional troubles in ruminants.

Where this deficiency does occur it can most severely restrict plant growth and affects nearly all crops.

Manganese

There is some indication that manganese deficiency may be of importance in parts of Canterbury. It is, however, more likely to be encountered as an excess, in which case it may give symptoms typical of molybdenum deficiency. Lime will suppress manganese uptake and has been used with beneficial effect on acid soils for this purpose. If we are to encounter manganese deficiency, however, lime may have adverse effects and this appears to have been the case in a number of trials in South and North Canterbury. J cannot deal fully with this deficiency, but it would appear at the moment that on the areas where it is suspected substantial improvement can be obtained with sulphur and phosphorus alone.

Boron

Boron may have special significance to Nelson and perhaps to parts of Central Otago and for special crops; otherwise it has not been shown to limit the initial improvement of any of the areas under discussion.

Lime

The significant features in regard to lime are:

1. Many areas can be greatly improved without lime, even though they may not reach their maximum production without it.
2. Lime has been effective in many areas indirectly by the release of molybdenum.
3. Lime has in many cases greatly assisted the nodulation of legumes.
4. Lime has in some cases suppressed excesses (possibly manganese most commonly).

5. Correcting molybdenum deficiency by adding molybdtnum is not as effective as: by adding lime on many soils, as lime has a number of beneficial effects which molybdenum has not.

6: Whereas it was considered that for good legume production lime was a major essential on most soils, it is now thought that once nodulation has taken place this may not be so.

7: It may be possible under some circumstances (and I stress some) to achieve' this nodulation with rates of lime as low as 2 to 3 lb per acre when used as a coating on the seed.

Because so many of the results which I have shown have been obtained without lime, I have not placed it among the great essentials.

Inoculation

As inoculation is dealt with in a later paper, I will only summarise the following points based on experiences of recent trials in Canterbury:

There are many areas where oversowings are satisfactory without inoculation.

There are some which are improved with inoculation, although they are relatively satisfactory without.

There are some which require inoculation as an essential treatment. These latter are, generally the most difficult areas and occur in, both dry and wet situations. They frequently have multiple fertility deficiencies.

On some areas where inoculation is a problem special treatments to obtain nodulation have been found to be:

(a) essential in a very few cases and

(b) slightly additive in effect to inoculation in several cases and

(c) quite unsuccessful, in some difficult, dry situations.

Of the special treatments, lime pelleting of seed has received the most attention and this has given results in a few cases. Other materials which may be of equal interest are charcoal (carbon) and magnesium carbonate. This latter has given plant responses in a number of areas which are almost certainly associated with its neutralsing effect on acid soils. This has been so in Canterbury, Marlborough, and Otago. Where magnesium carbonate has been used as a seed coating at very low rates it has in one case been considerably better than lime. Other methods of seed treatment require further study.

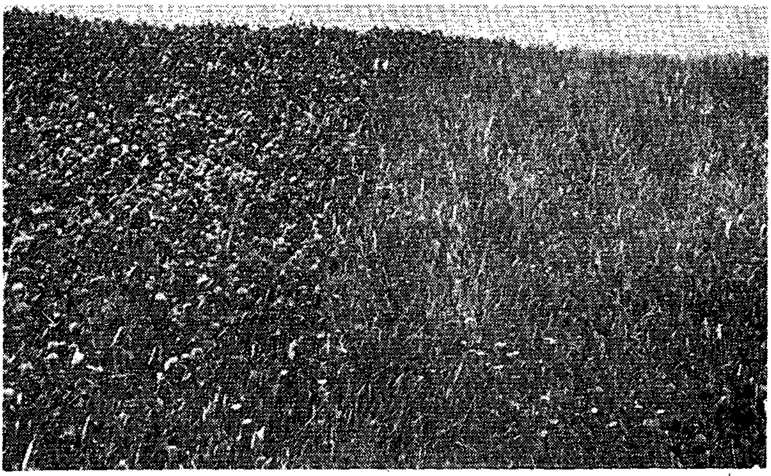
Where seeds have been sub-surface introduced on difficult sites, there has been some improvement in nodulation and this has been true in Otago, Canterbury, and Marlborough. It has not, however, been necessary to sub-surface introduce seed over a wide variety of soils provided oversowing time has been *suitable.*

Time of Sowing

Many of the best oversowing results have been with mid-winter sowings (June-July). There is some, degree of latitude in this respect and in general sowings can be later in districts of higher rainfall and in those which do not have early summer droughts.

Management

Management for establishment. and for early maintenance is also influenced by climate and season, but two points to consider are: very light or no grazing at establishment and a reasonable spell for flowering and seed setting in the first year, This latter is not essential where the climate is a perennial plant one, where fertility is going to be maintained by re-topdressing, and where the initial establishment is dense and even (which with aerial sowings is not very often, I'm afraid).



Molybdenum deficiency in red clover, North Otago, New Zealand. Left—Molybdenised superphosphate; right-D.D.T. superphosphate (both at. 1½ cwt per acre).

The implications of all that is stated above are many and some advances have been made to meet the variable situations.

The ratio of S:P needed will vary from district to district. However, in soil organic matter the ratio of S:P is normally 2:1 and is fairly constant, whereas the ratio in superphosphate is 3 :3: 1, indicating that in low organic matter soils only'65 per cent of the phosphorus could be utilised in organic matter build-up even if the whole of the sulphur available from superphosphate were used for this purpose; Thus, some variation in the S:P ratio of the fertiliser, and in the form of S may be necessary in some circumstances.

It is for this reason that fertilisers have been made available wherein the ratio of. S:P has been altered from the usual 1.3:1. A form of S other than gypsum has been used in these, giving, we think, a wider residual effect and *making **for far greater economy*** in the correction of sulphur deficiency.

The more common of these mixtures contain either 240 or 400 lb of added sulphur to the ton of the mixture. The sulphur is'of variable particle size, but all relatively fine, passing a IO-mesh sieve. This is much coarser than flowers of sulphur and in this respect would be slower acting. However, in these mixtures there is still the quick-acting S of the gypsum of the superphosphate.

The following table will show how the ratio of P:S and the amount of S as the element and as supplied by the gypsum of super-phosphate vary:

Brown hand print.

	P	S as Gypsum	S as element	S Total
Super	10	12.5	—	12.5
Super/240.S	9	11.2	12	23.2
Super/400.S	8.2	10.2	20	30.2
Super/800.S	6.4	8	40	48
Sulphur	—	—	112	112

The economics of correcting sulphur deficiencies can be worked 'out from the above and at present prices the cost of adding say 30 lb of sulphur per acre would be as follows (taking superphosphate at £10 and sulphur at £25 per ton and making no allowance for mixing, etc.)

	To add 30 lb S per acre Quantity in cwt	Cost per acre
Super	2.4	24/-
Super/240.S	1.3	15/1
Super/400.S	1.O	13/2
Super/800.S	.6	9/10
Sulphur	.4	6/8

Conclusion

It should be realised that a number of questions remain to be answered. By improving these areas with these fertilisers there is likely to be a very small fall in pH due to the build-up of organic matter through the combined action of the clover plant, the correction of S, P, and Mo deficiencies, and the grazing animal. This may or may not indicate that lime will be needed at some future date.

As for stock carrying capacity, it is not possible to measure what the effects of the improvement. of this class of country will be, as this is dependent on many factors other than soil fertility.

Important are the length of the growing season, rainfall, subdivision, management, stock replacement, elevation, topography, and frequency of storms. However, there can be no doubt that some very important changes could take place and that the impact of improving large areas of this lowly productive marginal land could have important influences on the economy of the South Island.

The following brief examples could illustrate this:

(a) A 1,000-acre property which in 395 l carried just under 1,000 total sheep (750 ewes) and 20 cows was by 1956 carrying 1,400 ewes, 1,050 dry sheep, and the same cattle.

(b) A 2,500-acre, low-altitude tussock run in 1952 carried 2,000 sheep and 30 cattle. After six years sheep have been increased by 1,200, cattle by 220, and wool production has increased by 15,800 lb, an increase of 2.5 lb of wool per head. The wool clip has in fact been doubled. Lambing has risen 15 per cent. There is no cultivable land on this run.

(c) An 8,000-acre property of which approximately 4,000 acres of the lower country has been seeded and topdressed, has increased from 3,680 sheep and a few cattle to 4,860 sheep and 154 cattle. Wool has increased by 7,300 lb or ¾ lb per head.

(d) A run of 4,370 acres running from 1,300 ft-4,100 ft, of which 220 acres only had been ploughed: Topdressing of natives started in 1951 and to date 1,020 acres have been fertilised and seeded. Topdressings including sulphur were used for the first time in 1957.

Stocking is shown below:

	1950	1958	1959 Intended Wintering
Ewes	1,300	2,020	2,300
Dry sheep	500	800	750
Totals	1,800	2,820	3,050
Cattle	Nil	154	200

Lambing has increased from 80 per cent to 110 per cent. In 1950, 500 store lambs and no *fats* were sold, whereas in 1958 *no stores* were sold and 1,260 fat lambs. Wool sold increased from 40 bales in 1950 to 76 bales in 1958, and, very important, the annual death rate, which was 8 per cent in 1950, dropped to 3 per cent in 1958.

On all the runs quoted, which stretch through Otago and South and North Canterbury, the health and quality of stock have improved and the cover and health of the introduced and native plants of these topdressed tussock swards have improved to a very marked degree.

This' paper could more correctly be titled "The Fertility Problems of the Marginal Areas" or perhaps "Some Aspects-of, Sulphur Deficiency on the Marginal Areas". This would not alter the context very much, because it should now be apparent that the development of the foothill country is entirely dependent on the correction of the mineral deficiencies which limit nitrogen fixation by the legume plant; that nothing spectacular is likely to be done without this step; and that other avenues of approach are bound to' be limited because of the very limits imposed by these deficiencies on any of the other steps likely to be taken.

DISCUSSION

Q. (—. Thomson): Has any further work been done with boron in Nelson following the initial trial?. What rates of boron were used on these areas?

A. A lot of work has been done in a large number of districts. The rate of borax used in Nelson was 10 lb per acre, but trials on pasture at 3, 7 and 14 lb have shown no difference except a quicker response to the higher rates.

Q. (-. Hobson): Would the application of boron before sowing clovers have any adverse effect on germination ?

A. Boron would not affect germination unless it were in direct contact with the seed.

Q. (A. G. Elliott): What difference has been noticed between the pelleting of seed with carbon and magnesium carbonate as against lime ?

A. Evidence is insufficient to say definitely. Possibly both magnesium carbonate and carbon are more efficient than calcium carbonate.

Q. (H. R. Scott): Please give some further information on the release of molybdenum by lime.

A. One can't generalise on this matter. An increase in pH makes molybdenum more available. This is certainly one of the beneficial effects that liming has had all over the country. But lime has more effects than the release of molybdenum, for instance, the increased bacterial activity obtained by correcting the lime status.

Q. (J. W. Woodcock): Would you advocate the application of ½ ton of lime and 1 oz of molybdenum in preference to 3 tons lime without molybdenum?

A. A generalisation cannot be given for all soils. Some benefit will be obtained in nodulation from ½ ton of lime but larger rates will have to be used on others to obtain a sufficient increase in pH.

Q. (Dr P. D. Sears): Are not free-living nutrifying bacteria negligible in importance in comparison with symbiotic forms?

A. Although this may be true, the importance of free-living forms in other aspects, the breakdown of organic matter and the turn round of sulphur cannot be ignored.

Q. (C. E. Iversen): What is the greatest altitude at which these spectacular responses have been achieved?

A. Up to 4½ thousand feet. Altitude is only one factor. Considerations of aspect, slope, etc., are equally important.

Q. (J. Graham): How does lime pelleted seed compare with seed sown with 2½ cwt of lime?

A. This comparison was not made in the series of trials referred to. There may have been a response to 2 cwt of lime.