SOME RESEARCH PROBLEMS.

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BECAUSE of a keen realization of the large number and the complexity of problems connected with grasslands, problems which vary with soil, climate, and systems of farming, it is with considerable diffidence that one ventures to discuss even a few of them. However, there are some which appear worthy of discussion and investigation and fundamental to the furtherance of research into certain other problems connected witli grasslands.

It is now sixty to seventy years since fertilizers were first used in New Zealand, and although the rise in the use of fertilizers, especially during the decade 1920 to 1930, was phenomenal, and the prosperity of the country is largely dependent on the use of fertilizers, we have not yet established anywhere in New Zealand experiments of a permanent nature to investigate the effects of continued use of various artificial fertilizers.

Rothamsted, the world-famous English Agricultural Research Station, and the first where the effects of fertilizers were studied systematically, has now been in existence for ninety-three years. The information that has resulted from the early classical experiments, which are still being continued, has been of inestimable value to agriculturalists all over the world and to English farmers in particular. The establishment of these experiments provides an example which might well be emulated in this country. With increased knowledge in respect to experiment-technique, fertilizers, plants, and animals, considerable improvement could be made in the design of such experiments compared with those originally laid down at Rothamsted. Their ultimate value would be increased accordingly.

Such investigations should be laid down with the object of their being continued for all time, or for at least so long as increased knowledge renders their cessation or alteration desirable. They should aim at the determination of the behaviour in and effect on the soil of various fertilizers and their effect on the chemical composition, yields, and nutritive value of plants. We are using, on some of our soils in New Zealand, larger quantities of phosphatic fertilizers than are being used anywhere else in the world, and so far no serious attempt has been made to find out what is happening to the unused residues of these fertilizers, nor how long such practices should and need continue. Our use of fertilizers is particularly one-sided, the bias being toward phosphate to the extent that we have developed a "phosphate complex." Admittedly there is, in the main, justification for this, but how long we can afford to go on as we are doing is a point which can be answered only by the establishment of permanent experiments.

In view of the importance of such investigations it might well be asked why these have not been established. There are several reasons. Firstly, those organizations, such as the agricultural colleges, which have the necessary security of tenure of land have not had sufficient finance, whilst organizations such as the Departments of Agriculture and Scientific and Industrial Research, which may, at some stage, have had the necessary finance, have not been possessed of the necessary

land. Secondly, the activities of all bodies which have conducted agricultural research have been directed mainly to the elucidation of what one might term current problems to the exclusion of less spectacular but highly desirable long-term investigations. In making these statements there is not the slightest intention of disparaging the past activities of agricultural-research organizations in New Zealand,, as the nature of the difficulties and limitations with which they have been confronted and the urgency for information on current problems are fully appreciated. There is, too, a persistent demand for results to justify research, which in the long run increases the difficulties of workers and forces them to seek for rarely achieved spectacular results. This leads to haphazard and disconnected lines of investigation instead of careful, thorough, and systematic planning.

The. time is overdue for the establishment of absolutely permanent experimental stations in some five or six of the more importarit and representative districts of New Zealand. These necessarily will vary from one another in respect of soil, and, even thou& climatic conditions may not differ greatly in some instances, the carrying-out of the same permanent investigations at all stations would undoubtedly. lead to information of great future value. The activities of these centres need not be confined to the type of investigation mentioned, but could, be extended to cover the investigation of current and local problems concerning each centre. The advantage of having different spil types on which to work was realized by the administrator% of Rothamsted, as is evidenced by their taking over the Woburn Experimental Farm in 1926, allowing them " to make experiments simultaneously on light and heavy soil."(I)*

Reference to current problems leads to a consideration of some investigations the solutions of which are of fundamental importance to further lines of research. The first is the technique of measurement of pasture production. In a paper read before this Association in 1933(2) the relationship between the nature of the problem and the technique to be adopted was discussed. The point to be emphasized here is **that** no particular technique is likely to be suitable for the investigation of all problems. The problem itself and the information desired has a considerable bearing on the technique which should be adopted.

The measurement of grassland production as influenced by strain or treatment is complicated by the fact that, unlike. annual crops, pastures produce a succession of " crops " throughout the year, the number of crops depending on the frequency of " harvesting " by man or beast. Further, the frequency and method of utilization of pasture has a considerable influence on its productivity as a whole, as well as on the individual species which contribute to its production. In addition, the value of any particular " crop " is likely to differ from that of another according to whether it is produced during a time of natural shortage or when there is a copious growth. Although it is difficult to adjust the effects of these various factors on the values of different crops from pasture, it is nevertheless desirable that any system of measurement should, be such as to enable production at all seasons of the year to be recorded. The alternate - mowing - and - grazing technique(g), which

* Numbers in parentheses refer to literature cited at end of the paper

enables this to be done in from'fifteen to twenty growth periods throughout the year, has proved eminently suitable for measuring production. of herbage accurately and comparatively cheaply. As at present carried out the effects of the various treatments are probably influenced by what is referred to as " transference of fertility." In the original article describing the technique(q), mention was made of the error introduced and of the intention of investigating its effect. Unfortunately, the opportunity 'to do so has not presented itself. A modification of the arrangement of plots(3) which would obviate the error mentioned was also suggested. As the modification entails an increase in the area required for an investigation and increased fencing and labour, its adoption would bc warranted only when and if it is shown that 'the technique as used at present introduces serious errors into the results. The alternate-mowing-and-grazing technique cannot be regarded. as suitable. for investigating all problems involving measurement of production, but it has proved so valuable in the past, and is likely to do so. in the future, that the. extent of its inexactitude is worthy of investigation. If, on investigation, the errors introduced are small, then the present procedure can be continued with confidcncc. If the errors prove unduly large, then it must be modified. It should be noted that such errors as are introduced favour lower yielding treatments at the expense of higher yielding ones, and to the extent that this occurs estimates of differences between compared treatments or strains, &c., are conservative rather than exaggerated., Further, it is only where there arc considerable differences between treatments 'under comparison that errors can be large. Where real differences are small the errors introduced are likely to be of little consequence.

The importance of having a satisfactory and accurate means of comparing the productive capacity of different strains in pasture-plants and treatments applied to them is fully apparent, and the investigation of technique is a proper 'preliminary to such comparisons.

A further problem which seems worthy of investigation, and which may be fundamental to the satisfactory comparison of strains of pasture-' plants and the more intensive study of 'fertilizer effects, is the reaction of strains to environment in so far as it is influenced by soil acidity or nutrient-supply.

It is not uncommon for inconsistent results from the addition of lime and fertilizers to be met with. The reference is not to inconsistencies in response, which can be accounted for by differences in soil and previous treatment, but to the type of variation in effect of treatment which one may get between one paddock and its neighbour. Usually such differences affect only 'the magnitude of response to a treatment and may occur under conditions which suggest 'that none of the factors' of soil, management, or -previous fertilizer additions--can- be responsible. There remains, thcrcforc, the possibility that strain may be the dominating influence. We have in common agricultural crops some outstanding examples of differences in tolerance for acid conditions. Rye-corn and oats, for example, tolerate and grow well under conditions of soil acidity. under 'which other crops such- as barley and wheat may fail. Differences in sensitiveness of crops to nutrient 'deficiencies also occur, as is well exemplified where wheat grows well without fertilizers but rape or turnips may fail entirely; It is not uncommon to find quite good crops of wheat being increased by 5 or 6 bushels by the addition of 1 cwt.

of superphosphate, and on the same soil a practical failure in the turnip crop being converted into a 12 to 20 ton yield by the addition of the same amount of fertilizer.

It seems not improbable, therefore, that differences of a similar kind, even if not of the same magnitude, may occur between strains of pasture-plants and be responsible for such inconsistencies in response to applied treatments as have been mentioned.

It took many years to recognize that the failure of rye-grass and white clover to persist, in many cases, was due to strain. Levy's work has indicated the importance of strain, but the extent to which strain is influenced by soil reaction and the level of nutrient-supply is not known.

As there are large differences between equally persistent strains in the production of leaf, so also it might be expected that similar differences in root development occur. Such differences are likely to affect the response of the plant to nutrient-supply if not to differences in soil reaction. What is the effect of the size of the root-systems on the ability of the plant to derive naturally occurring nutrients from the soil? What effect does the root-system have on the efficiency of utilization of added nutrients? Such questions can be answered only by experimenting. It appears desirable, therefore, to investigate the relationships between strain, soil reaction, and nutrient-supply as a preliminary to the more intensive study of the influence of added nutrients themselves.

The question of the position in the soil in which fertilizers are placed is another line of investigation which suggests itself as a worthy one. In respect to the manuring of annual crops, American workers have demonstrated big differences in the effects of fertilizers according to their placement relative to the seed. We have, too, the interesting development in Germany of the injection of solutions of fertilizers into the soil for the manuring of fruit-trees.

So far as the application of phosphate to grassland is concerned, there are some important aspects of the behaviour of superphosphate which warrant attention. It is well known **that** soluble vhosphatc, such as that in superphosphate, is "fixed" immediately it' comes in contact with moist soil, and that the nature of the compounds formed determines very materially the subsequent availability to plants of the added phosphate. The common practice of broadcasting fertilizers over the surface of the soil must result in the fixation of most .of the phosphate in the surface layer. One imagines that subsequent downward movement of the phosphate must occur to some extent in those soils on which top-dressing is effective. If it does not, it would only be at such times as the moisture content of the surface soil is above the point at which wilting occurs that plants would be able to make use of applied phosphates. In some comparatively dry districts, as in parts of Canterbury, top-dressing may have very little effect except in the early spring, when the moisture conditions in the surface layers of the soil are satisfactory. Under these same conditions a phosphatic fertilizer drilled into the soil to a depth of 2 in. to 3 in. when a crop or pasture is sown may be markedly effective, even during comparatively dry weather. These facts point definitely to the possibility of placement of phosphatic fertilizers having an appreciable influence on their availability to plants. Assuming placement in the soil to a depth of several inches is productive of better results than surface application, the cost of such incorporation in established pasture may more than offset the advantages.

However, the same difficulties do not present themselves in the manuring of pastures at the time of their establishment, and from this aspect alone placement trials would be well worth while. Experience has shown that increasing the fertility of the top few inches of pasture soils by making good nutrient deficiencies is highly important. We have no information, however, on the effect of a similar alteration in the fertility of lower and moister layers, and, since it is from these layers that plants must derive their nutrients as dryness of the soil increases, the logical expectation would be for greater efficiency of utilization of a nutrient such as phosphate when placed at some distance from the surface but still within the effective root range of pasture-plants.

In reviewing literature on the subject of the movement of phosphate in the soil Doak(5) drew attention to the fact that downward movement varied considerably, and was influenced by various factors such as soil type, rainfall, humus content, and lime status of the soil, and the form of phosphate applied.

No doubt all these factors influence the downward movement and effect of phosphate on plants in New Zealand, and an adequate study of the effect of placement on pasture response would necessitate the problem being investigated at various stations as suggested earlier in this paper.

A matter which calls for consideration is the basis of sale of ground limestone. This may appear to have no bearing on research, but in so far as research is necessary for the establishment of necessary standards it does have a bearing.

At least 250,000 tons of ground limestone were used in New Zealand in 1935–36(6), and the amount used is increasing rapidly. Figures for lime railed and on which railage is paid by the Government indicate that practically twice as much lime was used in 1935–36 as in 1927-28, eight years previously(6).

Despite the large and rapidly increasing expenditure on lime, farmers have no guarantee of the calcium-carbonate content or of the fineness of grinding of the material which they buy. The variation in calcium-carbonate content of limestone from different sources is well known. What is not sufficiently appreciated, however, is the extent to which fineness of grinding influences the agricultural value.

In the course of some recent investigations(7) commercial ground limestones from twenty different sources were analysed for $CaCO_3$ content and fineness of grinding. The $CaCO_3$ contents ranged from 56 per cent. to 96 per cent., and the fineness test showed that, on the average, 31 per cent. of the material was too coarse to pass a 30-mesh sieve. Some limes' contained between 40 per cent. and 50 per cent. retained on a 30-mesh sieve. (Note.-A 30-mesh sieve is one having 30 holes to the linear inch or goo per square inch.) American workers have shown that such relatively coarse material is of much less value even after a number of years than more finely ground limestone.

Work already in progress at the Marton Experimental Farm of the Department of Agriculture aims at a determination of the relative merits of coarse and fine material. In view of the influence of fineness of grinding on the efficiency of limestone and the effect of this in turn on the usefulness of the material to the farmer, it is evident that a fairly intensive study of the influence of fineness of grinding is warranted,

Pending definite results, -there is sufficient evidence from abroad to justify the laying-down of regulations requiring a statement of $CaCO_3$ carbonate content and necessitating better and guaranteed fineness of grinding.

Particular reference has not been made to the important question of the relationship of strains, pasture-mixtures, and fertilizer treatments to the animal- itself. The desirability of linking up the activities of the plant-research worker to those of the animal worker is obvious, and the problems of mutual interest to these workers are numerous. The problems discussed are only some of those with which research workers and the farming industry are confronted. Their relative importance is largely a matter of opinion and how they affect the individual. Obviously it is not possible to attack all problems immediately, but the time has arrived when more attention should be devoted to the organization of research, and at least as much attention should be paid to the careful planning for long-term investigations as is directed toward the elucidation of current problems.

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