THE

SCOPE AND LIMITATIONS OF SOME TYPES OF
GRASSLAND EXPERIMENTS.

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Before discussing the real subject matter of this paper
I should like to draw your attention to one essential difference
between the majority of our "annual" crops and pastures and the
influence of this difference on the results of experiments which
may be conducted on them. Generally speaking, the effect of any
treatment applied to an annual crop is determined by measurement
of the crop at maturity and any beneficial or adverse effect of a treat-
ment during the period of growth of the crop is likely to be reflected
in the yield when the crop is harvested or fed to stock as the case
may be. The production from pasture on the other hand is
represented by a succession of "crops" throughout the year or over
a period of years, the number of crops depending upon the method of
utilisation adopted. The treatment of one crop may have a profound
influence on succeeding ones. Consequently any system of actual,
measurement of the productive capacity of pastures as influenced by
various treatments should be so designed as to permit the recording
cf the production from each crop in the succession. Even though
this is done the interpretation of the results is not always easy
because the value of each pasture crop will depend very materially
on the extent to which it is needed or can be conserved at the time
when it is available.

Further, in the case of most experiments on annual crops
there is no great difficulty in measuring the whole of the ultimate
effect of treatments in the mature crop but with pastures the matter
is not so easy especially where stock are the instruments of
measurement. Fluctuations in production of successive crops of a
grazed pasture may be very considerable and in order to ensure
utilisation at an appropriate stage of growth considerable manipulation of stock is necessary. Obviously any experiment which does not measure the whole of the production resulting from treatments under comparison is subject to error as, although "no differences" may be the recorded result, quite considerable differences in the unconsumed and unmeasured excess may be present.

The question of grazing trials was very ably discussed in a paper read by Flay at the last conference of this association. What is designated by Flay "The Half-field trial" has many serious limitations but for certain comparisons of treatments can be extremely useful. Where differences in the productive capacities of treatments are likely to be large in relation to the errors associated with them, such trials may be sufficiently accurate to warrant their adoption in preference to more elaborate trials and are quite well suited on a standardised basis for the comparison of treatments in a number of places on farmer's own farms. This type of experiment has been applied recently to a determination of the relative merits of Certified Ryegrass and representative types of Non-certified Ryegrass in 6 places in Canterbury. During the first two years differences in carrying capacity in favour of the pastures sown with Certified seed have ranged from 8 to 93% with an average of 34%. Trials such as these meet with the requirements already stated of providing differences which are large in relation to the errors associated with them. Obviously the most desirable type of grazing trial is one in which accurate measurements are obtained of the production in terms of marketable products, milk, meat and wool. Contrary to the opinions of those who claim that such trials are easily conducted, I am definitely of the opinion, after somewhat limited experience, that such is not the case. Variations in soil and stock introduce considerable errors and the vagaries of weather conditions resulting in fluctuations in productivity and recoveries of growth in relation to the time and severity of defoliation of the

pasture all contribute to making such trials by no means easy as a means of acquiring exact information and valid results. The constant attention which has to be given to the movement of stock and the recording of relevant data limits such trials to specially supervised areas and this in turn limits their application to the solution of certain specific types of problems. I shall discuss this point more fully later.

"Haying" trials have been used extensively in the past for comparing different grassland treatments. Most commonly these have entailed the cutting of the herbage at a stage considered ideal for hay making and the weighing of it as cut. Results have been expressed in terms of green herbage or its hay equivalent. Such experiments have been comparatively easy to carry out, and although leaving much to be desired, have served a very useful purpose in New Zealand in indicating the effects of applications of fertilizers to grassland. Although the results have been subject to errors due chiefly to differences in stages of maturity of the herbage on different treatments at the time of cutting, the differences in the majority of cases have been sufficiently large to render such errors of little consequence.

I consider the chief disadvantages of haying trials to be as follows:

(1) Generally only one crop of hay is measured each year. This represents the production from the period when, as a rule, the rate of grass growth is at its maximum and under average existing conditions extra growth, at this time, is of less value than when natural production is lower.

(2) The measurement of production during the period of rapid growth gives no information regarding performance at other seasons of the year. A treatment such as a fertilizer, a seeds mixture or a strain of a pasture plant may show quite an appreciable difference from another treatment at one season of the year but no appreciable difference or a difference in the opposite direction at some other season.
(3) Haying of the same pasture each year for a number of years is not general practice and if carried out in an experiment, results may not be indicative of those obtained under average conditions where haying of permanent pastures alternates more or less with grazing throughout a complete year or more.

At the present stage of development in grassland knowledge in New Zealand I can see no particular value in haying trials for the comparison of treatments such as those already enumerated. In this connection, however, I would make an exception of crops of pasture plants of very short duration which may be sown specifically for the production of hay.

I think most of you are familiar with the technique for the measurement of grassland production which has been applied and developed during the last 5 years at the Marten Experimental Farm. I have described this technique in various publications and refer to it as the "Alternate mowing and grazing technique."

From point of view of determining the yields from various fertilizer treatments, seeds mixtures and strains of pasture plants, at all seasons of the year and under conditions comparable with those of rotational grazing, I feel justified in saying that this technique is highly satisfactory for application to a lot of problems affecting our medium or better class grasslands. It is not perfect - nor do I think it is applicable to the solution of all our grassland problems, but for providing information on such matters as I will indicate, it appeals to me as an accurate and comparatively cheap method. Like carefully conducted and more comprehensive grazing trials, it has the disadvantage, that it necessitates almost constant supervision and consequently must be confined to special experimental areas.

(1) Bulletin, No. 31 of the Department of Scientific & Industrial Research (Pt. 1).

(2) New Zealand Journal of Agriculture, August, 1931.

(3) A more complete and up to date description of the technique has been forwarded to the Imperial Agricultural Bureau (Herbage Plants) and I anticipate that this will be published shortly.
In any field experiment under measurement it is usual for some definite impressions to be gained from observation of the growing crop and it is always a matter of interest to find out how the impressions measure up against actual results. At times wrong impressions as to the direction of differences may result, particularly, in the case of pasture, if a relatively tall and open sward is being compared with a shorter and more dense one, the influence of density on yield being very difficult to gauge. However, as a rule, the eye of measurement proves a very good instrument of the direction of differences although an estimate of their magnitude, even for an experienced observer who has had considerable opportunity of checking up observations with measured results, may be subject to considerable error.

Providing preconceived ideas and bias resulting from a desire for a particular result do not influence judgment, "eye-measurement" can be a valuable aid to investigation and in fact plays a very important part in the general scheme of the grassland investigation work of the Department of Agriculture.

What we may term simple "observational trials" are laid down at hundreds of points throughout the country with the object of determining whether or not the soil responds to particular fertilizer treatments to an observable extent or whether one strain of grass or clover is superior to another under the existing conditions.

Experiments of this kind ask such simple questions as:

1. Does any of these treatments affect the growth of pasture?
2. Does this treatment combined with that have a better effect than either alone?
3. Do stock prefer the herbage in this treatment to the herbage in that?
4. Does this strain persist longer than that? and so on.

The answers provided are not always easy to interpret but in the majority of cases they are fairly clear cut and may be represented by one of the following:

1. None of the treatments, has influenced production to an observable extent.
(2) This treatment is apparently ineffective but when combined with that is markedly effective. etc.

Not infrequently a particular treatment may be only slightly though definitely effective and if it is a treatment not practised normally, the question arises as to whether its use is likely to be paying. On the other hand the results are often so outstanding as to leave no room for doubt regarding the economic worth of a particular treatment or treatments. The fact that results may be indefinite in some cases does not condemn trials of this nature. Some information, providing it is not grossly misleading, is better than no information at all, and if we refrained from doing experiments because they did not conform to what we considered the ideal, I am afraid we should not progress very rapidly.

I now propose to discuss some different problems and the relationship of technique to them. Consider firstly the type of experiment which aims at the determination of the economic value of a particular fertilizer or fertilizers. Naturally precautions will be taken to reduce those errors, which are incidental to all field experiments, to the minimum compatible with reasonableness. This may, and usually does, involve the adoption of precautions which make the individual experiment somewhat exacting so far as finance and supervision are concerned. This in turn limits the number of places in which such an experiment can be repeated with the result that the conclusions which may be drawn are very limited in the application. It is practically impossible to repeat exactly the results of an experiment. Even two exactly similar experiments in the same field or on the same farm will give different results, not in the direction of real differences, but in their magnitude. Such differences may be negligible but on the other hand they may be considerable, so that, strictly speaking, the results of any single field experiment designed to investigate the economic aspect of some particular treatment can be said to be true only for the particular area on which the trial was conducted in the particular season or seasons. Obviously it would be absurd to insist that this, the most
strict limitation, should be put on the results of even a single experiment, but the example helps me to lead up to the point I wish to make.

The point is that the results, interpreted in their economic sense, of any single field experiment, no matter how carefully it is carried out, suffer from the risk that they may not be sufficiently representative of the average even of the particular soil and climatic conditions represented by the site of the experiment. I do not wish to convey the impression that I am averse to such investigations. On the contrary I believe them to be most desirable, but as plots within an experiment are replicated, so experiments themselves, of this kind, should be replicated. If this is impossible then the results of any single experiment or of a few experiments should be viewed merely as a guide to the probability of a particular treatment being paying or otherwise. In the absence of reliable information on the economic value of a practice, farmers must try it for themselves and draw their own conclusions. If a practice becomes well established - but these are doubts as to its value which would rarely be the case, farmers being sufficiently discriminating not to be led badly astray - the economic survey method would appear to be the ideal means of determining its economic worth. The determination of the economic value of, say, certain fertilizer treatments on annual crops, is comparatively easily achieved by experiments, because experiments on annual crops are easier to conduct and can be more widespread and the results easier of interpretation; but no crop is so variable as "grass" nor subjected to such varying degrees of efficiency in its management. I have expressed my views on this subject because of the insistent demand for information on the economic value of practices affecting grassland production without any real appreciation, on the part of those soliciting such information of what is involved.

While discussing problems in relation to technique, I should like to say a few words about what I shall term:

A. "Particular experiments the findings from which are likely to be of more or less general application."
B. "Standard types of experiments the results of which are likely to be of more or less particular application."

Some examples of A would be such experiments as:-

(L) A comparison of a system of a set rate of stocking of pasture with a system of rotational grazing.

(2) A comparison of strains of Ryegrass or Clover.

(3) A comparison of infrequent heavy applications with frequent light applications of a particular fertilizer, etc.

The findings from investigations such as these would be applicable to practice within the soil and climatic range represented by the place of the experiment or and certainly in the case of the first example quoted - over a wider range of conditions.

Such problems as these could Justifiably be investigated at a reasonably representative experimental area and the results applied to localities under somewhat similar conditions. The third example is rather different from the others (and this applies to any investigation involving some principle in method and time of application of fertilizers), in that its prerequisite would be a soil markedly responsive to the treatment under trial. It would be useless, for instance, investigating the effect of methods or times of Phosphate of application on a soil which did not respond fairly markedly to phosphate applications.

The technique of measurement adopted in any investigations such as those quoted would depend on the problem:

Number (1) is obviously a stock grazing experiment.

Number (2) could be suitably investigated under the alternate mowing and grazing technique or under stock grazing, depending upon the information desired.

Number (3) would be ideally suited to the alternate mowing and grazing technique as differences in quality and its possible influence on stock would most likely be of little consequence and this technique would permit a greater degree of precision in the measurement of results from half an acre than would be attained with from probably 15 to 20 acres in a stock grazing trial.
Under the heading (B) I have in mind such experiments as might be laid down to determine the response to manures over a large area, such, for example, as New Zealand itself. We would not lay down an experiment using Lime, Phosphates and Potash at Lincoln College, and say that because certain results were obtained there, similar results would be obtained at Cheviot, but there is no reason why the same type of experiment should not be laid down in both places to determine the effects of the treatments mentioned. This in effect is what is being done as rapidly as facilities will permit throughout the more intensely settled districts of New Zealand.

We are conducting a response-to-manure-survey with simple observational experiments.

I should certainly like to carry out simple grazing trials even though they were less freely distributed, but the expense and supervision entailed makes this impossible. Consequently we are doing what is considered the next best thing and I am convinced from experience that the adoption of this method of experiment has justified itself by the results and information obtained. I would go even further and say that it is a desirable forerunner of more comprehensive trials as it is possible to determine very rapidly the major limiting factors to production so far as fertilizers are concerned, and indicate, the nature of the more comprehensive trials if such are possible in the future.

In conclusion I should like to refer to the not uncommon criticism that determination of yield in itself is not a satisfactory basis of measurement. This criticism, usually directed against fertilizer trials, generally arises out of the assertion that although a particular treatment may not increase the yield the improvement in "quality" is sufficient to justify its use. Of the common fertilizer materials, Lime, Phosphates and Potash, it is generally recognized that on soils deficient in any of these, the use of lime on a lime deficient soil will increase the Lime content of herbage; Phosphates on a phosphate deficient soil will increase the Phosphate, Lime and Protein contents, and Potash on...
deficient soils, will increase the Potash content and depress the Lime. My definition of a soil deficient in any or all of the constituents mentioned is one on which pasture growth will be increased by their application providing no other factor is limiting such effect. If the particular constituent is not a limiting factor to production in the yield sense, I know of no evidence which can justify its use on the score of "quality" alone. Yield and improvement in quality may not be influenced in the same proportion when a deficiency is made up but I am firmly of the opinion that where a plant food is not so deficient as to limit plant production to an appreciable extent that any loss in quality from the animal production point of view is not a serious one. I consider, therefore, that increases in yield which do not take the quality factor into consideration on the side of being conservative in the estimate of their value. Not a bad fault.