THE BRITISH ASSOCIATION AT BOURNEMOUTH.

SECTION M.

AGRICULTURE.

OPENING ADDRESS (ABRIDGED) BY PROF. W. SOMERVILLE, D.SC., PRESIDENT OF THE SECTION.

DURING the past four years—or since the ploughing programme began to take shape—grass-land has been officially cold-shouldered in no small degree. The cause was obvious and the reasons were good. The result of compulsory and voluntary ploughing has been that, whereas in 1914 the total area in Great Britain under temporary and permanent grass (hay and pasture) was practically 21,500,000 acres, it was barely 19,500,000 acres in 1918, a reduction, namely, of about 2,000,000 acres. During the same period the arable area, other than temporary grass, increased from about 10,500,000 acres to 12,500,000 acres. In Ireland during these years the area under grass (permanent and temporary) fell from about 12,500,000 acres to less than 11,250,000 acres. The United Kingdom at the present time comprises about 30,500,000 acres of permanent and temporary grass and 15,500,000 acres of land under crops other than grass and clover. This is over and above some 16,000,000 acres of mountain land used for grazing.

A considerable proportion of the grass-land of this country is of so high a quality that any improvement, and certainly any economic improvement, is hard of accomplishment. Satisfactory as are the high-class pastures of this country, it by no means follows that there is nothing more to learn about them. It is often very difficult to determine the factor or factors that go to the making of high-class pastures. Such pastures are to be found on most of the geological formations of this country; they are met with north, south, east, and west; and even altitude, within the limit of at least 700 ft., seems to have little effect. An immense amount of attention has been given to the botanical composition of the herbage of the more famous of the pastures of Britain. The result that emerges most conspicuously from these researches is that one may have a dozen pastures which are about equal in feeding value and yet may vary widely in respect of botanical composition. Thus Fream found that in the case of forty-eight English and eight Irish pastures, each of which was the "best" in the district selected, the Gramineæ might be as low as 11 per cent. and as high as 100 per cent.; Leguminosæ might be entirely absent or as high as 38 per cent.; while of miscellaneous herbage, most of which would be designated as "weeds," there might be none or up to 89 per cent. As regards individual genera and species, Fream found, for instance, that Agrostis was almost always present, and on five occasions was the most abundant plant; while *Holcus lanatus* gave an almost identical result. By a different method Carruthers arrived at a very similar conclusion. The latter also found that *Hordeum pratense* was the most abundant species on what is perhaps the finest grazing in England, namely, Pawlett Hams, near the mouth of the Parret, in Somerset. This investigator even found that on one of the "famous ancient pastures of England" the predominant grasses were Fiorin and Hassock, and in this connection makes the following remark, "In this field the hassock-grass, which made up a large proportion of the pasture, was freely eaten, and the cattle were in good condition."

In Hall and Russell's investigations Agrostis and Holcus might on occasion each exceed 20 per cent., and it is stated that "wherever *Holcus lanatus* occurs it is more abundant on the fatting fields." Even miscellaneous herbage could bulk more than 29 per cent. on a pasture so good that it could fatten five bullocks on four acres without cake. Armstrong found in a field representative of "the richest type of old grazing land found in the Market Harborough district" that, amongst grasses, *Poa annua* came second (12·3 per cent.) in point of abundance. There will be general agreement that four of the grasses just mentioned, Fiorin, Yorkshire Fog, Squirrel Tail, and Hassock, are accounted "bad," and yet it is hard to apply this term to plants which are the most abundant constituents of some of the finest pastures in England. While there is much that is disconcerting in these investigations, some facts do emerge with satisfactory consistency:—(1) That the great majority of high-class pastures contain a large proportion of perennial ryegrass and white clover; (2) that crested dogstail is almost always present, though rarely predominant; (3) that meadow fescue is practically negligible; and (4) that of the two Poas, *pratensis* and *trivialis*, the former is very rare, while the latter is very common.

The obvious deduction to be drawn from these investigations is that the quality of a permanent pasture is only in a minor degree determined by the relative abundance of its constituent plants, or, in the words of Hall and Russell, "We can only conclude that the feeding value of a pasture is largely independent of the floral type." Factors of much greater weight are depth and physical character of the soil, soil moisture and temperature, density of the herbage, and the natural or induced composition of the soil as regards plant-food, and especially in respect of phosphoric acid.

It seems that the lesson that may be learned from a study of the old pastures of England is that we need not include in a seeds mixture for permanent purposes plants which never bulk to any considerable extent in old grass-land, but that we should include all those which are usually naturally abundant. Take, as an illustration, the case of perennial ryegrass. In the eighties of last century, when much interest was taken in the subject of the best way to lay down land to grass, an almost violent controversy arose over the desirability or otherwise of including perennial ryegrass in a seeds mixture for permanent pasture. The main opponents of ryegrass were Faunce de Laune and Carruthers, who would have excluded this species in all circumstances. It is a common experience of those who have laid land away to grass with ordinary commercial seed that perennial ryegrass does not persist, but neither, for the matter of that, does white clover. And the probability is that the cause in both cases is to be found in the same direction. Both these plants, as usually grown in this and other countries for seed, are the progeny of a long line of cultivated ancestors, grown under somewhat forcing conditions which may be said to undermine the "constitution." They have adapted themselves to their artificial environment, and such adaptation has taken the form of early maturity and the production of a large yield of "bold" seed which is easily marketed. Gilchrist has, of late years, directed attention to the merits of wild white clover, which, as regards persistency, is on an altogether different plane from the cultivated or Dutch white. The price that farmers are willing to pay for the seed of wild white clover is the best proof of the sharp distinction which they draw between the two varieties. What we now want is similar work on grasses, and particularly on perennial ryegrass, and it is satisfactory to know that such work has actually been started.

Important as is the position of the fine old pastures of England in the agricultural economy of the country, and interesting though it may be to examine questions of seeding, a much more important line of inquiry is opened up by the problem of the improvement of our second- and third-rate pastures. What proportion of the grass-land of the country falls into the lower categories it is impossible to say, but the most superficial acquaintance with rural England is sufficient to carry conviction that the aggregate area of such land is enormous. Most of the poor grass-land of the country is associated with the heavier classes of soil, and has been abandoned to grass on account of the high costs of cultivation, including, in many cases, the necessity of drainage. It is, for arable purposes, essentially wheat-land, with an occasional crop of beans, and the regular intervention at comparatively short intervals of a bare fallow. Other areas of poor pasture, smaller in aggregate extent than the clays, but still of much importance, are to be found on all the geological formations of the country. Of the 14,500,000 acres of permanent grass in England and Wales, 70 per cent. is under pasture and only 30 per cent. under hay, and of the poorer classes of grass-land it is certain that the proportion that is grazed is still greater. It is evident, therefore, that the improvement of pasture is relatively a more urgent matter than the improvement of meadows, though with more than 4,250,000 acres of permanent grass made into hay in England and Wales during 1918, the latter problem is also one of enormous importance. The most famous experiments on the effects of manure on permanent hay are those started in 1856 by Lawes and Gilbert on the meadow at Rothamsted, and continued ever since on the lines originally laid down. The results have thrown a flood of light on the principles of manuring, which has been of the greatest assistance in the elucidation of problems in agricultural chemistry and soil physics. They have also shown unmistakably the effects of the more important elements of plant-food on the yield of hay and on its botanical composition, but, even supported as they were by elaborate chemical analysis of the produce, they leave us uncertain in regard to the feeding value of the herbage.

A very large number of experiments have been carried out which had for their object the determination of the quantitative results attributable to the use of manures, singly and in combination. In many cases these experiments were supported by a botanical, and not infrequently by a chemical, analysis of the resultant herbage, but it was felt that we were still in a state of much uncertainty in respect of the quality of the hay—that is to say its effect on animals consuming it. This induced Middleton in the winter of 1900–1 to carry out a feeding experiment with sheep at Cockle Park, and in 1905–6 and 1907–8 Gilchrist continued and amplified this work. The sheep were accommodated in a special house. The various lots of sheep all got equal quantities of roots, cake, and hay. The hay employed was the produce of variously manured plots on old grass-land which I laid out in 1897. The soil is a clay loam on a boulder clay subsoil. This set of experiments includes the eight-plot test, and it may be interesting to see what influence nitrogen, phosphoric acid, and potash respectively have on the produce. The quantitative figures refer to the average annual yield for twenty-one years, 1897–1917, while the figures which indicate the relative values of the produce, as determined by the live-weight increase of sheep, are based upon the feeding tests already specified. The hay from the unmanured plot, No. 6, is assumed to be worth 4*l.* per ton. The results are set out in the accompanying table:—

Plot	Manuring per acre per annum	Average annual yield of hay	Value per ton of hay as determined by feeding
		cwt.	*s. d.*
6	Unmanured	19¼	80 0
7	30 lb. N in Sulphate of Ammonia	23	72 0
8	50 lb. P_2O_5 usually in Basic Slag	20	93 0
9	50 lb. K_2O in Muriate of Potash...	16	80 0
10	30 lb. N + 50 lb. P_2O_5	30¼	84 0
11	30 lb. N + 50 lb. K_2O	21	72 0
12	50 lb. P_2O_5 + 50 lb. K_2O... ...	26	101 9
13	30 lb. N + 50 lb. P_2O_5 + 50 lb. K_2O	30½	89 2

Nitrogen derived from sulphate of ammonia, and used at the rate of 30 lb. per acre per annum, has consistently increased the yield and as consistently reduced the quality. When used alone the nitrogen has increased the crop by 3¾ cwt. per acre, and reduced the feeding value of the hay by 8*s.* per ton. When added to phosphates, the nitrogen has increased the yield by 4¼ cwt. and reduced the quality by 9*s.* per ton. When nitrogen was added to potash the yield has been raised by 5 cwt. per acre, and the value lowered by 8*s.* per ton. When used as an addition to both phosphates and potash the nitrogen has increased the yield by 4½ cwt. per acre, while the value has fallen by 12*s.* 7*d.* per ton. Even if the quality of the hay be disregarded, the use of nitrogen has always been attended by an adverse financial balance; when quality is taken into account this undesirable result is greatly emphasised.

As regards phosphoric acid, an increased yield has been consistently obtained by its use, accompanied in every case by a marked improvement in the quality of the hay. Taking the arithmetical mean, the increase in quantity has been nearly 8½ cwt. per acre, while the increase in quality is represented by 16*s.* per ton.

The behaviour of potash is rather peculiar. It has quite distinctly reduced the yield when used alone or when used in combination with nitrogen only, while in both these sets of circumstances it has had no influence one way or other on the quality of the hay. When added to phosphates it has proved powerless to increase the yield, but it has raised the feeding value of the hay by 8*s.* 9*d.* per ton. When added to both nitrogen and phosphates the potash has been practically inoperative so far as yield is concerned, but it has improved the quality by 5*s.* 2*d.* per ton.

These results show that very erroneous conclusions may be reached if, in experimental work on meadow hay, attention is given only to the weights of produce secured. Thus, in these Cockle Park experiments, on the average of twenty-one years, if quantity alone be regarded, sulphate of ammonia used by itself has involved an annual loss of 6*s.* 4*d.* per acre, whereas, if the reduced quality of the hay be taken into account, the loss is increased to 15*s.* 7*d.* per acre. On the other hand, a quantitative gain of 4*s.* 2*d.* per acre per annum from the use of phosphate and potash is raised to one of 32*s.* 5*d.* owing to the superior quality of the hay. While there is a certain relationship between the chemical composition, the botanical analysis, and the feeding value of the hay, there will probably be general agreement with Middleton when he says that "without an appeal to the animal, the relative values of samples grown under different treatment cannot be measured." In my view, this form of research may, with advantage, be largely extended.

Turning now to the improvement of pastures, as contrasted with meadows, it may be remarked that while no sharp line can be drawn between these two classes of grass-land in respect of ameliorative treat-

ment, there are certain distinctions which must be kept in view. In a meadow the plants are allowed to grow up to full maturity, whereas in a pasture they are cut over daily, or at least very frequently, by the grazing of the animals. It is difficult to arrive at a decision as to whether a larger gross weight of dry material is got from a given area treated as pasture, in contrast to being hayed, but the probability is that the aggregate quantity is greater. Take the analogy of a patch of lucerne. Cut three or four times in the season, it may yield six tons of dry matter per acre, cut once it would certainly yield much less. Or take the case of cocksfoot; this springs so quickly in the aftermath that the foliage may shoot up 6 in. almost in as many days, whereas there would be no such growth were the hay not cut over. It is a matter of observation, too, how quickly red clover springs up after cutting, and trees and shrubs which may be growing only a few inches annually when unrestrained may send up stool shoots several feet in length if cut over. It is difficult, however, to bring the question to the test of figures.

If there is any doubt as to the greater weight of dry matter produced under a system of grazing, there can be none in respect of its digestibility. This would appear to be the reason why sheep and cattle will fatten on a pasture, whereas the animals would only remain in store condition on the herbage if made into hay.

At one time experiments on the improvement of pasture took the form of temporarily enclosing an area, to which different methods of treatment were applied and of determining the results in terms of hay. Supplementary to such quantitative determination, chemical analysis and botanical separations were often made, but it is evident from the work of the investigators already quoted that the results so obtained may be a very untrustworthy index of the feeding value of the herbage. In any case, the competition between the various classes of plants may be very different in a hay field and in a well-grazed pasture. Again, in a hay field the produce is reaped and cleared off with all the plant food which it contains. In a pasture, on the other hand, there is the daily conversion of vegetable substance into manure and its immediate return to the land. Reflections of that sort induced me in 1896 to arrange a series of experiments where a direct appeal was made to the animal. We all know that among a lot of animals there are certain individuals which possess idiosyncrasies which result in their thriving better or worse than the others. By careful selection, however, and especially by keeping them under observation for a probationary period, this objection may be largely eliminated. The greater the number of animals, the more completely is any disturbance due to individual peculiarities got rid of, and for this reason sheep are usually employed in preference to cattle. No one who looks into the details of these "manuring for meat" experiments can doubt that, not only in broad outline, but even in the finer details, the results are perfectly trustworthy. Involving as they do considerable outlay on fencing, water, weighing machines, etc., and necessitating the use of large areas of uniform land, such experiments were not likely to be undertaken with great frequency, but I have been able to find reports of nine in England, twelve in Scotland, two in Ireland, and one in New Zealand. Two of them are situated at Cockle Park, of which the original in Tree Field has now completed its twenty-third season, while the other in Hanging Leaves has a record of sixteen years.

The outstanding feature of these experiments is the great and profitable effect of phosphates. In this material the farmer is placed in possession of an agent of production the effects of which on the output of meat, milk, and work from the pastures of this country are only limited by the supplies. In many cases the increase of meat is trebled, and even quadrupled, with a return on the original outlay that runs into hundreds per cent. As between the various sources of phosphate there is unmistakable evidence that basic slag is the most effective, not only in respect of aggregate yield of meat, but also, and more particularly, when the net financial return is considered. This conclusion is also reached by Carruthers and Voelcker in a long series of pasture experiments carried out in 1896–99 for the Royal Agricultural Society of England. In these experiments, however, the effects were only estimated by ocular inspection. The primary effect of phosphates is due to the marked stimulus that they give to the growth of clovers and other Leguminosæ, and as these plants revel in a non-acid soil the alkaline character of basic slag appears exactly to suit their requirements.

In regard to the quantity of phosphatic manure that can most effectively be employed per acre, it would appear that in the case of inferior pasture a heavy initial dressing, say 200 lb. of phosphoric acid or more per acre, is likely to be nearly twice as effective as half this dressing, and therefore actually much more profitable. To secure the best results the Leguminosæ must be rapidly brought up to their maximum vigour, so that they may fully occupy the ground before the grasses have had time to react to the effects of the accumulated nitrogen.

One of the most striking results of these pasture experiments is the long period over which the action of phosphates persists. Even at the end of nine years the meat-producing power of half a ton per acre of basic slag is far from being exhausted. It is not suggested that this persistent action of slag—and no doubt this applies also to any other effective phosphate—is due to unappropriated residues. It is much more probably due to two other causes: (*a*) to the fact that on a pasture, in contrast to a meadow, manurial elements are kept in circulation from the soil to the plant, and from the plant to the animal, and so, to a large extent, back to the soil again; and (*b*) to the accumulation of nitrogen in the form of humus. Poor, unprofitable grass is chiefly associated with clay, and it is fortunate that it is precisely on such land that clover responds so markedly to phosphatic manuring. But conspicuous results have also been obtained on deep peat, on light stony loam, on thin chalk, and on chalk covered by clay with flints. Middleton has very fully discussed the conditions under which phosphatic dressings may be expected to give results, and ascribes an important place to soil moisture, on which white clover is directly very dependent. The only conspicuous case of failure of phosphates to improve pasture was encountered in Norfolk, where a "manuring-for-mutton" experiment was started in 1901. The soil at that station was a hot, dry, sandy gravel containing 60 per cent. of sand, and there both the basic slag and superphosphate were unable to produce any improvement. Wood and Berry attribute this result partly to the presence of abundant natural supplies of citric soluble phosphoric acid, but chiefly to lack of moisture. In reporting on the R.A.S.E. experiments Carruthers and Voelcker in 1900 had already directed attention to the dependence of basic slag on soil moisture.

We may now look at the effect of supplementing phosphates with certain other substances. And, first of all, as regards potash. At most of the manuring-for-mutton stations, both in England and Scotland,

there was a plot devoted to the elucidation of the effect of this substance, and although in the great majority of cases the phosphate-*plus*-potash plot has shown more live-weight increase than phosphates alone, it is only in very rare instances that the gain has been a profitable one. Even on thin soil overlying chalk, potash has had little action on pasture. There are several rather conspicuous instances of quite moderate dressings of potash doing positive harm. Thus, at Cockle Park, whereas potash gave an appreciable increase in live-weight in the first nine years, it proved positively and progressively injurious during the next two six-year periods. Even on a "light stony loam" in Perthshire, Wright found that, although in the first two years potash when added to slag gave a conspicuous return, in the next three years "the advantage was wholly with the slag-alone plot." The most notable beneficial effect of potash was obtained in Dumfriesshire on a station where the mineral soil was overlaid by 10 ft. of peat. There the use of kainit supplying 100 lb. of potash per acre at the beginning of the experiment has in seven years produced 70 per cent. more meat than phosphate (slag) alone, while the financial gain has been improved by nearly 50 per cent.

Potash has had great influence both on the yield and composition of the hay on the meadow at Rothamsted, and it would seem that this substance has more effect on a meadow than on a pasture. The reason is probably to seek in the fact that in a pasture the top layers of the soil are constantly being enriched by the potash brought from the subsoil by plants and returned through their excreta. In any case, pasture plants on clay soil are in possession of abundant supplies of potash, and it is only where pasture occupies sandy, gravelly, or peaty soil that this manurial element need be seriously considered.

Lime as an addition to superphosphate was tested at the three original manuring-for-mutton experiment stations, a total of 30 cwt. per acre being applied in three dressings in nine years. A noticeable effect was produced at all stations, and at two of them the gain was a profitable one. The effects of lime can be followed for twenty-one years at Cockle Park, where the soil naturally contains 0·59 per cent. of calcium carbonate. During that period an aggregate of 5½ tons per acre was applied in seven dressings, the phosphate to which it was added being superphosphate in the first nine years and basic slag in the next twelve. The area receiving the lime was the same throughout. The action of the lime has proved to be a progressively decreasing one. On the average it produced an annual increase of 22 lb. live-weight in the first nine years, and of 8 lb. in the next six years, whereas in the concluding six years of the period it has actually caused a reduction in live-weight of 8 lb. per acre per annum.

The addition to superphosphate of moderate dressings of nitrogen in the form of sulphate of ammonia or of nitrate of soda was tried at the three main manuring-for-mutton stations, and at two others. There is no need to go into a detailed discussion of the results. The evidence is overwhelmingly against the use of nitrogen on pastures. It undoubtedly stimulates the vigour of the non-leguminous herbage, but this reacts on the growth of the clovers, with the result that the production of meat is sometimes, as at Cockle Park, actually and substantially reduced.

At the three original stations dissolved bones were also tried, the comparison being with equal quantities (200 lb. per acre in nine years) of phosphoric acid derived respectively from basic slag and superphosphate. The dissolved bones supplied in addition from about 50 lb. to 40 lb. of organic nitrogen. All manures were applied as to half in the first year, and, as to the other half, at the commencement of the fourth season, the experiment being continued for nine years at Cockle Park and Sevington (Hants) and for eight years at Cransley (Northants). At Cockle Park slag acted substantially better than dissolved bones, though the latter surpassed the effect of superphosphate; at Sevington dissolved bones proved inferior to both the other manures; while at Cransley the position was reversed. But when the cost is considered there is no question of the superior merits of basic slag. This superiority is continued and emphasised at Cockle Park, where the experiments are now at the end of their twenty-third year. A similar result was also obtained in the series of pasture experiments conducted by the Royal Agricultural Society of England already referred to. There dissolved bones or bone-meal was tried at ten centres, with the result that "in Herefordshire some benefit was observed, but in the other places no real improvement could be detected as compared with the unmanured part of the field. So far as these investigations go, therefore, they indicate that no further experiments need be made with bones on pasture land."

With these results before us it is needless to pause to consider whether the comparative failure of bones, dissolved or raw, is due to the inferior quality of their phosphate or to the fact that they supply the land with nitrogen.

A form of pasture improvement which has had, and still has, much support amongst farmers is feeding with cake. The manure applied to the land through cake residues is a "general" manure, supplying nitrogen, phosphates, and potash, of which that which has the highest value attached to it is the nitrogen. At eleven of the stations in England and Scotland reported on in the Supplement to the *Journal of the Board of Agriculture* in 1911, linseed or cotton cake, or a mixture of these cakes, was used for two, four, or five years, and at every one of them the live-weight gain secured was insufficient to pay for the outlay, the debit balance per acre per annum being in one case nearly a pound. In connection with the improvement of pasture, however, it is the residual effect of the cake that has most interest. This matter was put to the test at eight of the manuring-for-mutton stations in the following manner. At the three original stations cake was fed all through the season for two years, and none given for the next four. At five of the other stations cake was fed for two or four years, and was then suspended for one, two, or three years. In this way the improvement of the herbage effected during the years when cake was fed had an opportunity of manifesting itself in the form of live-weight increase in the years immediately succeeding, when no cake was given. In every case the residual effect was found to be appreciable, having a money value per ton of cake consumed of as much as 4*l.* 14*s.* at one station, and 3*l.* 11*s.* at another, the average for the three stations where the residues were followed for four years being fully 3*l.* per ton, a figure which is of the same order as, though somewhat higher than, those adopted by Voelcker and Hall in their revised table of 1902.

A method of improvement of poor pasture that deserves notice consists in scattering the seed of a "renovating" mixture over the surface, usually with concurrent harrowing, rolling, and manuring. This procedure was practised in the series of experiments conducted by the Royal Agricultural Society of England, the seed mixture consisting of four natural grasses in addition to white clover and yarrow. In their final report Carruthers and Voelcker stated that

re-seeding had not been successful, a result which they thought was "entirely due to the prevalence of dry seasons, the germinating plants being killed before they could get hold of the soil." A more successful result is reported by Middleton, who on a poor pasture on clay soil in Essex sowed, in the spring of 1903, 12 lb. per acre of wild white clover seed, with and without basic slag, kainit, and lime, this treatment being unaccompanied by harrowing. There were no Leguminosæ naturally present in the field. Helped by abundant rain in the summer of 1903, the seed germinated well, and "in 1904 the results were very marked." It was, however, only when the seeding had been accompanied by basic slag that "there was the luxuriant growth which one expects in pastures where Leguminosæ are present." I also have reported on an experiment where renovating a thin, poor pasture with 6 lb. per acre of wild white clover seed was entirely successful, and here, too, the beneficial effects were only secured in the presence of basic slag.

When a responsive pasture is treated for the first time with, say, half a ton of basic slag per acre, the effects reach their maximum usually in the third season. From then onwards there is a steady diminution in the yield, though even after nine years from the time of the initial dressing the improvement is far from being exhausted. At Cockle Park, for instance, the plot dressed once with half a ton of slag was, at the end of nine years, producing three times as much mutton as the continuously unmanured ground, while at Sevington and Cransley the yield at the end of nine and eight years respectively was 70 per cent. to 80 per cent. greater. None of the other stations was carried on for so long a period, but up to the end of the sixth year most of them show residual fertility which is as great as the original rental value of the land. That is a very important result, but in the interests of the country it is still more important to endeavour to secure that the level reached at the period of maximum productivity shall be maintained.

From this rapid survey of grass-land experiments the following conclusions may legitimately be drawn:—

(1) That the quality of a pasture is not primarily dependent on its botanical composition, though, as a rule, the presence of white clover and other Leguminosæ is indicative of high feeding value.

(2) That poor pastures, especially on clay soil, can be rapidly and profitably improved by the use of phosphates, especially basic slag.

(3) That, as a rule, phosphates alone are necessary to effect and maintain the improvement, and that, of supplementary substances, potash and lime are occasionally worthy of attention.

(4) That the improvement of poor pasture is very dependent on the presence of Leguminosæ, and especially of white clover.

(5) That renovating with the seed of wild white clover may, in the absence of natural Leguminosæ, be a necessary preliminary or concurrent operation.

(6) That cake can rarely be used at a profit, and that, as an agent in improving poor pasture, it occupies an unsatisfactory position.

(7) That nitrogen, whether in the form of artificial manure or as cake residues, when added to phosphates for pasture, is always unnecessary and frequently detrimental.

(8) That in the case of hay on permanent grass-land, equal weights of produce may have very different feeding values.

(9) That few forms of agricultural expenditure are more certain in their results than the judicious use of manures on grass-land, and that the meat and milk-producing capacity of the country can be largely and rapidly increased, with great pecuniary gain to the farmer, and still greater economic advantage to the nation.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

BIRMINGHAM.—Mr. C. Grant Robertson, tutor in modern history since 1905 to Magdalen College, Oxford, and a stimulating lecturer upon national development, has been appointed to succeed Sir Oliver Lodge as Principal of the University.

CAMBRIDGE.—Mr. K. J. J. Mackenzie has been re-appointed reader in agriculture. Other appointments are:—Mr. W. J. Harrison, University lecturer in mathematics; Mr. A. Wood, University lecturer in experimental physics; Mr. A. G. Tansley, University lecturer in botany; and Mr. F. Balfour Browne, University lecturer in zoology.

DURHAM.—Members of the University are invited to help in compiling the definitive edition of the Roll of Service and Roll of Honour. The latest date for receiving forms framed to include all details of military service is December 31. The address of the University offices is 38 North Bailey, Durham.

EDINBURGH.—The University Court has made the following appointments to three newly instituted chairs:—Dr. G. M. Robertson to the professorship of psychiatry, Dr. J. H. Ashworth to the professorship of zoology, and Mr. T. P. Laird to the professorship of accounting and business method.

The following appointments have also been made:—Dr. F. E. Jardine as lecturer on applied anatomy, and Dr. David Lees as lecturer on venereal diseases.

The Right Hon. Lord Lyell of Kinnordy has presented to the geology department forty-six volumes which had formed part of Sir Charles Lyell's library when he was preparing his "Principles of Geology."

The late Mr. Samuel Elliott, of New York, has bequeathed to the University Court the sum of 1500*l.* to be held in trust by it for the purpose of applying the income in providing scholarships or prizes in connection with the classes of the professors of rhetoric and English literature and of ancient history and palæography, the scholarships or prizes to be known as the James Elliott scholarships or prizes, in memory of the testator's brother, James Elliott, who was a student and graduate of the University.

At the last meeting of the Munitions Committee, South-East of Scotland Area, a sum of 500*l.* was set aside to be expended in providing additional equipment for the engineering laboratory.

LIVERPOOL.—Mr. T. E. Peet has been appointed to the Brunner chair of Egyptology, and Dr. J. Share Jones to the chair of veterinary anatomy.

LONDON.—Dr. Sydney Russell Wells has been elected Vice-Chancellor in succession to Sir Cooper Perry, who has been appointed to the post of Principal Officer.

Sir Richard Glazebrook has been appointed to the Zaharoff chair of aviation tenable at the Imperial College of Science and Technology, founded by Sir Basil Zaharoff, who gave to the University the sum of 25,000*l.* for this purpose.

Dr. A. P. Newton has been appointed, as from September 1, 1920, the first occupant of the newly established Rhodes chair of Imperial history tenable at King's College.

Prof. W. Bulloch has been appointed, as from January 1, 1920, the first occupant of the newly established Goldsmiths' Company's chair of bac-