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A.Y. MONTGOMERY.

THE USE OF NITROGEN FERTILISERS ON PASTURES IN NEW ZEALAND

SECTION I.

INTRODUCTION AND HISTORICAL.

Prior to the World War, the quantity of readily available Nitrogen fertilisers such as Nitrate of Soda and Sulphate of Ammonia which were applied to grasslands in any part of the world was insignificant in comparison with present day conditions, Two factors changed this state of affairs.

In the first instance, the manufacture of Synthetic, Nitrogen compounds using the free Nitrogen of the air has enormously increased the amount of suitable Nitrogen fertilisers which are available. Sir John Russell states that 11.5 million tons of Nitrogen fertilisers were used in the year 1930 and that production was increasing. This compares with a world consumption of **11.3** million tons of Superphosphate for the year 1931. The price of such nitrogen fertilisers as Sulphate of Ammonia is approximately ½ that of ten years ago.

At the same time there has been a more or less world-wide wave of enthusiastic enquiry into the possibilities of increasing returns from pastures. This has been aptly expressed by our late Governor General, Lord Bledisloe, who states. "Just as the Eighteenth Century is associated with a progressive revolution in arable husbandry, and the Nineteenth a similar leap forward in live stock husbandry, so the Twentieth Century is calculated to rank in history as affecting a like revolution in "Grassland Husbandry."

Here in N.Z. where so much of our livelihood depends on pastures, it is natural that there has been an enquiry into ways and means of utilizing Nitrogen fertilisers so as to produce more and a more uniform supply of pasturage in every month of the year. We are informed on good authority that so fas as many of our best grass-growing districts are concerned, no country in the world has such favourable climatic and other conditions for continuous pasture growth. It is to the' fact that our pastures are so continuously productive, that we in N.Z. owe our greatest chance of competing successfully with overseas producers of butter, lamb and other elaborated grass products.

While most American, South African and Australian pastures are liable to long periods of drought, and Canadian and Northern European pastures are put out of action by their long cold Winters, our pastures can go on producing at a high level at all times of the year.

Competitive stock raisers overseas 'have a limited amount of difficulty in supplying their animals with roughages for "maintenance" purposes during their drought or Winter conditions, On the other hand, they find a great deal more difficulty in providing adequate quantities of the protein-rich foodstuffs which are so important in the production of milk and flesh. I have enquired in England regarding the expenditure which English farmers

are forced to make on concentrates. An annual expenditure of 20% of their gross takings on concentrates is not unusual on many Danish and English milk producing farms. Not all of these concentrates are essentially protein-rich, but a good proportion of them are. Whilst English and Danish farmers are buying in expensive protein-rich concentrates, we are able to produce leafy pasturage, the dry matter cf which has a protein content of from 20% to 30%.

One of the chief reasons why we are able to overcome the disadvantages of being 12,000 miles from our chief export market lies in the fact that our climate allows of our growing protein-rich fodder in every month in the year, and, of course, our climate also obviates th e necessity of housing and hand feeding the stock under cover.

The role of Nitrogen fertilisers on pastures in N.Z. is 'to supply protein-rich, milk and flesh producing grass, just at a time when it is needed most in the Winter and Early Spring. In this regard it is interesting to note that Sir E.J. Russell states. "The impossibility of purchasing concentrated stock foods led Warmbold at Hohenheim, to extract as much grazing as possible from the land, and he did this by the liberal use of Nitrogenous and potassic fertilisers, both of which were available in large quantities."

Our President, Mr. A.H. Cockayne, realised this clearly when some years ago he analysed the position regarding Nitrogen utilization in the N.Z. dairying industry as follows:-

(1) Early calving is essential to high herd production under the N.Z. system of dairying,.

(2) Early calving cows must be adequately provided with feek--producing d in the early Spring.

(3) The ordinary farm cannot adequately replace Spring grass , shortage by roots , ensilage , or hay, either alone or in combination.

(4) A really adequate supply of vigorously growing young grass in the early Spring consumed as such, would make early calving safe and effective throughout N. Z.

During the pas-c few years quite a number of New Zealanders have been engaged in trying to define the exact conditions under which Nitrogen fertilisers will be most useful to *N.Z.* pasture end other farmers. Members of the Department of Agriculture and of all other Scientific bodies interested in Agriculture, as well as farmers themselves, have been actively interested. There have been many successful and many unsuccessful attempts to utilize Nitrogen fertilisers,

In the past there has been a tendency to lump together the results of both successful and unsuccessful experiments, and in consequence no clear idea has been obtained of why a particular experiment was a success or a failure.

The aim of this paper is to point out that the work of

determining the factors which make for success in the use of Nitrogen fertilisers, is not completed, On the one hand we have indisputable evidence that -the most used Nitrogen fertiliser, Sulphate of Ammonia, can and does under certain conditions 'produce a "slump" in production following on its use; on the other hand, we have a good many hundreds of farmers who use Sulphate of Ammonia or Ammoniated Super regularly on the same pasture year after year, and they have completely satisfactory results. It must be admitted that the best results are confined to high production grasslands, and a Nitrogen fertiliser which could be used over a wider area would be a great asset to N.Z. Pasture' farmers.

From an historical point of view, it is evident that a great deal of new enthusiasm concerning the intensive system of grassland farming incorporating the use of Nitrogen fertilisers came to us from Germany by the way of Great Britain during 1926-27. Professor Warmbold at Hohenhsim had demonstrated that greatly increased returns could be obtained from pastures under intensive management including the use of Nitrogen. The results of the German experiments were brought to England by Mr. T.H J. Carroll B.Sc. (Agric.), F.R.H. S., and by 1927 74 farm scale experiments were established in Great Britain to demonstrate, if possible, what could be done by treating grass as a crop, At the same time Dr. H.R. Woodman at Cambridge University was demonstrating the high feeding value of leafy grass, Professor Stapledon at Aberystwyth was demonstrating the possibilities of selected strains of pasture plants, and Dr. Orr and Major Elliott at the Rowett Institute, Aberdeen, were investigating the mineral content of various types of pastures.

When Nitrogen fertilisers were tried out seriously in N.Z. on pastures during 1926-1930 a great deal of really new knowledge concerning pastures was undigested by most grassland workers the world over, and certainly not much was known about how to use Nitrogen on pastures. It is not surprising that results to 'date have been confusing. One thing seems clear and that it is that most of those who experimented- with Nitrogen fertilisers had an exaggerated idea of the quantity of Sulphate of Ammonia or Nitrate of Soda etc. which could be applied per acre continuously to the same pasture. Mr. Carroll in the April 1927 issue of "Farm Notes" recommended the use of 5 cwt. per acre of Sulphate of Ammonia. Today most N.Z. farmers who are using Sulphate of Ammonia do not apply more than 1 ½ cwts. of Sulphate of Ammonia on the same pasture continuously.

SECTION II.

SOME GENERAL OBSERVATIONS ON THE USE OF NITROGENOUS PLANT FOODS ON PASTURES.

Sir E. J, Russell states that the most obvious effects of applications of Nitrogenous plant foods is a change to a deep green colour and an increased rate of growth due to an increase in leaf size, which is followed when not used in excess by a larger plant not greatly different in composition from smaller plants of the same kind which did not receive Nitrogen. Excess of Nitrogen definitely disturbs

the carbohydrate-Nitrogen balance in the plant and, produces a sappy growth liable to disease.

From a mineral composition point of view, excess of Nitrogen results in a plant with a lowered Potash and Calcium content, but the percentage phosphate content is not 80 lowered. The result of the extra growth due to Nitrogen is, however, to draw a more than usual amount of Ca, K_2O, and P_2O_5 from the soil, This explains at once one reason why it is essential that Nitrogen fertilisers should be applied only to those pastures which are maintained at a high level as regards available phosphate, potash and lime.

Sir John Russell states in general terms that when Nitrogen fertilisers are applied to the mixed herbage we call pasture, the following effects are produced.

(1) [Increase in total crop.
2(Increased rate of growth in the early part of season.
(3)A continuance of growth after cutting or grazing and at the end of the season.

He states, "Success depends on proper grazing and on giving a complete fertiliser with sufficient calcium carbonate to ensure that the soil shall not become sour."

NITROGEN FERTILISERS AND THE MICRO-ORGANIStiS OF THE SOIL.

When Sulphate of Ammonia, for instance,. is applied to the soil, profound changes immediately take place in the microbiological population of the soil. On the type of the change which takes place depends the nature of the effect which we may expect from the fertiliser in producing additional pasture growth. Whenever an explanation is offered as to the success or otherwise of an application of Sulphate of Ammonia, the microbiological changes should be studied as accurately as possible.

One fruitful method of gaining knowledge of the fate of Nitrogen fertilisers when applied to a particular soil, is to study the amount of Nitrogen lost in the drainage waters, and also the soil content in regard to "Total,"nitrite, nitrate and Ammoniacal Nitrogen, before and for some months after the applications. If other conditions are suitable for pasture growth, topdressing with such a fertiliser as Sulphate of Ammonia should be successful in proportion to the degree to which the soil lacks available Nitrogen.

It is noteworthy that in most,, if not all, N.Z. Pasture trials, there has been no attempt to guage what has happened to the applied Nitrogen plant food from a soil organism view point. It is also interesting to ***note*** that when the Waite Institute of South Australia investigated the use of Nitrogen fertilisers on wheat, oats'and barley crops the Nitrogen status of the soil was investigated at regular intervals during the course of theexperiments. The result has been a ready under-'standing of field results. It has been shown that the Australian practice of bare-fallowing land for a year, results in an accumulation of soil Nitrogen, equivalent to approximately $3\frac{1}{2}$ cwts. of Sulphate of Ammonia per acre.

Crops sown on fallowed land do not respond to and do not require Nitrogenous fertilisers, but where the land is ploughed out of stubble and sown almost immediately In the same Autumn to another grain crop, the soil lacks available Nitrogen and Nitrogen fertilisers show striking increases on stubble sown crops.

SOME MICROBILOGICAL EFFECTS OF APPLYING SUCH A NITROGEN FERTILISER AS SULPHATE OF AMMONIA ON PASTURES.

It is impossible to over emphasise the fact that the use of Nitrogen f'ertilisers brings about far reaching changes in the microbiological population of the soil, and in the nature of these changes depends the success of the fertiliser application.

Some of the well-established facts, concerning the possible microbiological effects of applying such a Nitrogen fertiliser as Sulphate of Ammonia to pastures are mentioned briefly as follows;-

(1) Nitrogen fertilisers do not supply all the Nitrogen requirements of pastures. Nitrogen f'ertilisers are applied to make up a temporary deficiency of available Nitrogen which results from a slowing up of the bacteria.1 processes which make Nitrogen available to plants under the best growing conditions. In the warm "flush" months of pasture growth in N.Z., our high production soils evidently contain an abundance of readily available Nitrogen, but under the cold wet conditions which obtain during our Winter and early Spring it is evident that much available Nitrogen is either locked up bacterially or is leached from the soil. Practical results show that the addition of some readily available Nitrogen in the form of a Nitrogen fertiliser greatly increases the-growth of our pastures during the Winter and early Spring. The drainage, shelter and lie of the land to the sun are all factors which influence the results from Nitrogen fertiliser applications.

(2) Prolonged locking up of Nitrogen fertilisers by bacteria takes place when the soil is too cold and wet. The above mentioned effect offers one explanation why Nitrogen fertilisers should not be applied in Southland to pastures which are not growing owing to a prolonged spell of very cold weather.

SECTION III.

SOME COMMENTS ON EXPERIMENTS WHICH HAVE BEEN CARRIED OUT IN N.Z. TO DEFINE THE EXACT CONDITIONS UNDER WHICH NITROGEN WOULD PROVE USEFUL TO N.Z. PASTURE FARMERS.

There have been three types of' experiments conducted on N.Z. Pastures with the object of gaining knowledge of' the utility of Nitrogen fertilisers.

(a) OBSERVATIONAL EXPERIMENTS.

A full report on the experiments which were conducted in Canterbury during 1928 to 1930 is contained in the Oct.-Nov.-Dec. 1930 and Jan-. 1931 issues of the N.Z. Journal of Agriculture. The comments regarding Sulphate of Ammonia

are as follows:-

'Nitrogen -- Responses to nitrogen were particularly consistent, over 80 per cent. of the experiments falling in the "Fair" to "Good" classes so 'far as this factor was concerned. Generally speaking, the. better the rycgrass and cocksfoot content of the sward the better the response to nitrogen, The best results, too, were obtained where the nitrogen plot crossed lime plus super,, although very often the super plus nitrogen plots were good.

In practically all experiments the best plot of the series was that receiving lime plus super plus nitrogen. It must be remembered, however, that from the commencement of the trials until May, 1930 - just under two years - most of the experiments had received 5 cwt. of nitrogenous fertiliser per acre at a cost of about £3.5s per acre. In addition to tne perioa of two to three months after application, when the nitrogen exercised a direct influence, there has been a general improvement in the grass sward. The growth of clover has been reduced in a good many cases, but as a rule the reduction in clovers did not appear to be serious on the lime plus super plus nitrogen plots. We do not venture an opinion as to whether or not the use of nitrogen at its present price is paying. This must depend on a number of factors; but one thing is certain, namely, that nitrogen will not pay on pastures which are lacking in the major species of grasses - ryegrass and-or cocksfoot.

To those farmers who desire to try nitrogen, our advice is:- (1) Use it on pasture which has been limed and phosphated (2) Use it only for the production of early Spring grass by applying it in late July or early August, and possibly for production of early Winter feed by applying in March *or* April (3) Use it on good pastures only (4) Feed off the resultant growth while it is still young and palatable. These remarks apply only to pastures used for grazing purposes.

The Canterbury and other similar observational top-dressing trials in N.Z. further showed the importance of managing the extra grass, grown by the aid of nitrogen.

(b) STOCK GRAZING EXPERIMENTS.

The experiments aimed to compare the number of stock carried on Phosphate-lime treated areas, and *on* Lime, Phosphate, Nitrogen treated areas. Mr. A.W. Hudson has summarised the chief objections to stock grazing trials as follows:-

(a) They require relatively large areas of ground, which makes replication of treatments costly and difficult, and are suited only to comparison of treatments causing relatively large differences.

(b) Large numbers of stock are required.

(c) Errors associated with stock measurement are great.

(d) Unless the whole of the herbage produced is consumed the results are further subject to large errors.

Somefarmers, such as J. Ranstead of Matangi, J. Hirstisch of Patumahoe and J. Ashworth of Taneatua, who used Nitrogen in these trials realised the benefit of growing Winter and Early Spring grass and adapted the methods used in the trials to their own farming conditions and are still using Nitrogen regularly. The trials failed to give a measure of the usefulness of Nitrogen fertilisers under practical farming conditions;

(c) ALTERNATE MOWING AND GRAZING TRIALS.

Alternate mowing and grazing trials conducted by the Department of Agriculture at Marton and Ruakura. A report on these experiments is contained in Bulletin 31 of the N.Z. Department of Scientific and Industrial Research. These trials were conducted most conscientiously and have given some valuable information regarding the use of Nitrogen fertilisers on pastures in N.Z.

The Trials have shown:-

(I) That about 1 cwt. of Sulphate of Ammonia is a suitable amount to apply at any one topdressing.

(2) That heavy dressings up to 6 cwts. of Sulphate of Ammonia per acre per annum caused a reduction of pasture production 'in the summer following an initial increase in production from Spring or Autumn dressings. The degree of reduction in production varied considerably in different trials and with different forms of Nitrogen, and increased when the Nitrogen applications were 'continued.

Criticisms which have been levelled at the alternate mowing and grazing technique which was used point out that the stock droppings from one manurial treatment are distributed on other manurial treatments. It is also contended that the alternate fairly close mowing and sheep grazing do not afford a close enough parallel with conditions which obtain under practical dairying conditions, where fairly "long" crops of grass are grown and where Nitrogen treated pastures are not "bare" grazed in the Winter. It may yet be proved that the stage at which Nitrogen-treated grass is cut or consumed has a vital influence on the after health of the pasture plants. When a grass plant rapidly absorbs a large number of Ammonium ions, the carbohydrate/Nitrogen balance of the plant is altered. If the plant is allowed to make a good leafy growth carbohydrates are produced and the Nitrogen/carbohydrate balance brought back to normality. Close grazing of Nitrogen-treated grass before it has had time to make leafage may yet be proved to have an important bearing on the reason why Nitrogen-treated pastures sometimes show a reduction in yield some months after treatment,

The trials reported in Part IV of Bulletin 31 have been criticised on the grounds that no lime was applied. Part V'of Bulletin 31 reports on the mowing trials at Ruakura. The technique adopted was mowing only in the first season, alternate mowing and grazing in the second and third seasons.

No lime was used in these trials. Part VI of Bulletin 31 reports attempts to minimisc the "slumping" effects of Sulphate of Ammonia by applying lime and by altering the frequencies of cutting the plots. Unfortunatelythese plots were mown only and not grazed. According to Bulletin **31,** the practice of mowing and removal of the pasture growth, removesplant foods approximately as follows from a pasture during a e a r . (Estimate is conservative **for** high yielding pastures. 3

55lb.	Lime	CaO	Approx. Equal	to 98 lbs.	$CaCO_3$ per acre
37 **lb.**		P_2O_5	" "	" 185 lbs.	Super (44% tri-calcic Phosphate) per acre
150 lb.		K_2O	" "	" 500 lbs.	30% Potash Salts per acre
150 lb.	N itrogen		" "	" 750 lbs.	of Sulphate of Ammonia per acre.

The removal of such large quantities of plant foods coupled with the botanical changes which take place under a system of mowing only has proved a serious drawback to trials conducted under the "Mowing only" system.

It must be admitted that a great deal more enquiry is necessary before we can say that we have answered a large number of the questions which vitally affect the utilization of Nitrogen fertilisers on N.Z. Pastures.

SECTION IV.

WHAT FARMERS HAVE LEARNT REGARDING THE USE OF NITROGEN FERTILISERS ON PASTURES IN N.Z.

A good many thousands of N.Z. pastures farmers have been . using Nitrogen fertilisers during the past few years. Some have had disappointing results and some have had such satisfactory results that they now regularly include the use of a Nitrogen fertiliser in their topdressing programme.

In this section the writer will confine himself to the results obtained by intensive dairy farmers in the North Island. There are regular users of Nitrogen Fertilisers among the dairy farmers of the South Island and among the sheep farmers and pasture seed producers of both Islands, but the writer's observations of practical results have taken place chiefly among North Island dairymen. Some features of the use of Nitrogen fertilisers on North Island dairy farms are as follows+

(1) There is a generally felt want among dairymen for a "protein rich" fodder, to supplement the usual rations of hay, ensilage and/or roots, which are provided in the Winter and early Spring. Nitrogen-treated grass provides a milk-producing food just when it is most needed.

(2) Nitrogen fertilisers are applied to good ryegrass pastures. Ryegrass grows well in.the Winter if well supplied with suitable plant foods. As a rule at least three pastures are topdressed with Nitrogen so as to provide a succession of crops of Winter and Early Spring grass.

(3) The, pastures chosen'are for preference well

sheltered, well drained and lie well to the sun. They must be in good heart and well supplied with regular dressings of lime, phosphates and on some soils, Potash. These pastures receive approximately 5 cwt. of ground carbonate of lime every second year, and 3 cwt. of super per acre per annum. High carrying capacity areas with a high soil Nitrogen content such as "night" paddocks are the most suitable for treatment with Nitrogen fertilisers.

(4) The most used Nitrogen fertiliser is Ammoniated Super, a fertiliser works mixture of 2 parts Super and 1 part Sulphate of Ammonia in which a certain amount of chemical reaction has taken place with the formation of Ammonium phosphate. Many farmers also make up their own super-sulphate of Ammonia mixtures.

Ammoniated Super is usually applied at from 3 to 4 cwts. per acre. This dressing is usually regarded as additional to the usual annual topdressing with Super, Lime and Potash.

(5) TIMES OF APPLICATION.

Nitrogen fertilisers are applied for the production of Winter and early Spring grass at any time during the months of March, April, May, June, July and August and September according to when the extra pasturage is required, This in turn depends largely on the dates of calving of the milking cows.

(6) The treatment of the pasture prior to the application of the Nitrogen fertiliser has an important bearing on results. Pastures should not be grazed hard by stock for a lengthy period prior to the application of the fertiliser. Lenient grazing in the Autumn and early Winter is followed by good crops of Winter and early Spring grass, It is absolutely essential that the grass should be arowing when the N. Fertiliser is applied. It is quite worth while to allow a pasture to establish 1" to 2" growth before applying a Nitrogen fertiliser dressing.

(7) Any burning effect of the fertiliser can be overcome by applying it during rain.

(8) After application of the Nitrogen fertiliser the pasture is spelled and a crop of grass at least 6" to 7" is grown.

(9) The pastures are grazed on a lenient rotational system. They are never bare-grazed and thus make a good recovery after each spell of grazing. The pastures continue to grow throughout the cold weather, and do not "frost." "On and off"' grazing may be carried out but is recognised as a practice which is exhausting owing to the removal of stock Nitrogen.

(10) After treatment of Nitrogen-treated pastures varies with different soil and pasture conditions as follows:-

(a) Where the soil is rich and the carrying capacity of the pasture high, as is typically the case on "night" paddocks, a crop of ensilage or early hay is usually cut, following the taking of crops of Winter and early Spring grass.

After this the pasture is grazed for the remainder of the summer to encourage white clover growth.

(b) On medium dairying land the advisability of taking a crop of ensilage or hay following the growing of crops of Winter and early Spring grass, depends on the vigour of the white clover growth in the late Spring and Summer. If the white clover is not growing vigorously in the Spring, following the Winter grass, the area should not be ensiled or hayed, as this practice tends to allow the top grasses to smother the white clover. Fairly hard rotational grazing encourages white clover growth.

(c) On light dairying land experience shows that pastures which are utilized for the growing of crops or Winter and Early Spring grass, should not be ensiled or hayed in the same year as the Winter grass crop is taken. In order to strengthen white clover growth it may be necessary to top-dress in September with 1 to 2 cwts. of Super per acre,

Other purposes for which practical farmers are utilizing Sulphate of Ammonia and Ammoniated Super are as follows:-

(1) For "topdressing back" pastures which contain a good percentage of a good type perennial ryegrass, which is comparatively non-productive owing to being starved of essential plant foods, The use of Ammoniated Super for the above purpose has been the means of greatly increasing the productivity of many unsatisfactory pastures,

(2) To "bring up" the ryegrass in paspalum-ryegrass pastures. In most paspalum-ryegrass pastures the ryegrass does not throw much feed until September and October, and if the paspalum is controlled in the summer months, renovated and topdressed in April or May with for instance, 3 cwt. of Ammoniated Super, it is possible to encourage a rye-dominant growth quite early in the Winter.

(3) Proper management plus the application of Sulphate of Ammonia or Ammoniated Super is used to produce a grass-dominant sward for feeding in the Spring months on farms where "clover bloating" or hoven occurs in cattle.

(4) An investigation by Mr. E. Bruce Levy and other members of the Department of Agriculture and the Department of Scientific and Industrial Research has shown that a serious "feed flavour" occurs in some N. Z. dairying areas, owing to the pastures containing too high a percentage of clovers. The investigation suggests that this trouble can he overcome by management and the use of Sulphate of Ammonia, Nitrate of Soda or another Nitrogen fertiliser so as to produce a grass-dominant sward.

(5) Some Nitrogen fertiliser is frequently used on hay and ensilage crops and for the production of seed crops of ryegrass and Chewings fescue.

An accurate description of the manner in which N.Z. pasture farmers are adapting the use of Nitrogen fertiliser to their own practical farming conditions is described from time to time in our farming papers such as "The Exporter," "The N.Z. Farmer," and "The N.Z. Dairyman." A number of such descriptions are contained in Appendix I of this paper.

CONCLUSION,

There can be no doubt that crops of Winter and early Spring grass can play a most important part in the feeding of our sheep, cattle and pigs. Quite a number of the members of the Grassland Conference have been actively interested in the work of defining the conditions under which Nitrogen fertilisers can be used to help produce. "protein-rich" pasturage in the cold wet months of the year.

In this paper I have endeavoured to show that there are many aspects of Nitrogen utilization which are not, as yet, fully investigated, The conditions under which Nitrogen fertilisers failed to give satisfactory results; on pastures have been widely published and much discussed, One of the chief objects of this paper is to point out that under some conditions Nitrogen fertilisers are being used with complete success on N.Z. pastures.

It is hoped that a discussion of the conditions which govern the successful use of Nitrogen fertilisers on pastures and a consideration of some typical examples of successful usage may be productive of further enquiry into the whole question of Nitrogen utilization in N.Z.