SOME ASPECTS OF POTASH MANURING OF PASTURES.

J. W. WOODCOCK, Fields Division, Department of Agriculture, Wellington.

POTASSIC fertilize& take a -minor place among artificial manures in New Zealand as compared with most other countries, particularly those in Europe. For instance, in relation to the amount of phosphate used, the comparative figures for New Zealand and a few other countries are approximately as follows :—

country.	Ratio of Phosphoric Acid (P_2O_5) to Potash (K_2O) used.*	
	P_2O_5.	K_2O.
New Zealand	30 to 50	1
Italy	7	1
Switzerland'	$3\frac{1}{2}$	1
Great Britain	3	1
Sweden	$2\frac{1}{2}$	1
France	$1\frac{1}{2}$	1
Germany	$\frac{1}{2}$	1

* Adapted from tables in *The Fertilizer,* Feeding *Stuffs, and Farm Supplies* Journal, N.Z. *Jour. Aghc.,* and Year-Book of International Inst. of Agric., Rome.

The wide difference is no doubt due to the systems of farming, since the countries contrasted with New Zealand are largely arable,, and such potash-demanding crops as sugar-beet and potatoes form an appreciable part of the area under cultivation. Nevertheless, it is significant that the potash-prdducing countries Germany and France. tire the chief users of the material in its " artificial " form, although a perusal of literature and photographs, particularly from Germany, almost suggests that providence has mercifully placed deposits of potash where they are likely to be most needed.

TREND OF POTASH MANURING IN NEW ZEALAND.

The quantities of potash fertilizers imported into New Zealand fell considerably from 1929 to 1934. This is attributable largely to the lower purchasing-power caused by economic conditions and the increased cost of potassic fertilizers brought about by exchange and other import restrictions. In spite of this, some farmers have steadfastly continued to use potash in addition to phosphates, but many who had hitherto incorporated it into their manuring practice preferred to reduce expenditure by cutting out the use of potash, and used only phosphatic fertilizers or phosphates with lime, and even reduced their applications of these niaterials. This reflects the attitude of the New Zealand farming community generally to manuring practice--i.e., phosphate, by reason of its spectacular effect in converting poor pasture into good and its known ability to increase appreciably the stock-carrying capacity of most farms, is

indispensable. Potassic and nitrogenous fertilizers, on the other h&d, are viewed as mere accessories to increase production over and beyond the initial improvement effected. by phosphates:

It is generally consider&d that far more phosphoric acid than' potash is removed 'in the major Products from New Zealand farms, but in the. removal of meat, wool, wheat,. butter, cheese, potatoes, and milk. for human consumption* approximately 10,000 tons of potash (K_2O) are taken annually, as compared with 14,000 tons of. phosphoric acid (P_2O_5), a ratio of 1 to 1·4. Milk for butter and cheese. manufacture has been included in the estimate, but most of the fertilizing, elements from milk for manufacture of these are returned to the farms, although not: necessarily to the land,. by way of separated milk and whey. The position, then, is of interest if viewed. from the angle that in 1934 about 72,000 tons of phosphoric acid (P_2O_5) and about 2,000 tons of potash (K_2O) in artificial fertilizers went on to farms in New Zealand, while over 14,000 tons of P_2O_5 and more than 10,000 tons of K_2O were removed in the main products for human consumption. It is realized, of course, that such data. cannot be taken as a criterion of the immediate fertilizer needs of our farm crops, but; on the other hand, it is obvious that this state of affairs cannot continue indefinitely, and that, sooner or later, potash manuring must take a more prominent place in fertilizer practice.

It has been stated frequently that New Zealand' soils are generally well supplied with available potash, and it is quite obvious that on most soil types this element is in much greater supply than is 'available phosphate. In certain areas; however, assuming that soil analysis is a reliable guide, there arc indications that no great surplus of potash exists, and it is on these that potassic fertilizers are likely to become necessary in the near future. The reliability of, soil. analysis in this' connection will be discussed later.

THE NEED FOR POTASH MANURING ON PASTURES.

Under normal' conditions grass takes up about four times as much potash as it does phosphate. Hudson(I) estimates that if all the herbage from a pasture producing 5,000 lb. of dry matter a year were- removed it would be equivalent to the taking-off of 55 lb. lime (CaO), approximately equal to 98 lb. of carbonate of lime ; 37 lb. phosphoric anhydride, approximately equal to 185 lb. of superphosphate ; 150 lb. of potassic' oxide, approximately equal to 500 lb. of 30-per-cent. potash salts ; 150 lb. nitiogen, approximately equal to 750 lb. sulphate of ammonia. He further Stated that under stock-grazing the amount returned to the pasture through the animal varies according to whether young stock, milking-stock; or--mature dry stock are used. In the case of mature dry stock it is considered that most of the lime, phosphate, and, potash, and a large proportion of nitrogen, is returned. The potash returned to -the land through the stock is in a highly available form, and is easily utilized by the next. generation of plants. Russell(z) states : "-Dairy cows permanently remove more potash

* Estimated from production figures for 1934 N.Z. Year-book, A. 'and P. Statistics, and based on tables in the " Agricultural Notebook " (McConnell) and " Feeds and Feeding " (Henry and Morrison).

than bullocks, as also do growing sheep for their wool. This is shown by the fact that the quantities, in pounds, of potash (K_2O) removed annually per acre in a grazing season are bullocks, 250 lb. live-weight increase, 0·5; dairy cattle, 300 gallons milk, 5·0; sheep, 200 lb. live-weight increase, 30 lb. wool; 2·0. Heavy soils can supply all the potash needed, but light soils continuously used for sheep-grazing may ultimately fail to do so, and dressings of kainit may become necessary when the yields of mutton and of wool are being increased by basic slag. Where a hay crop is annually removed the supply of potash decreases, and unless more is added the yield falls to a lower level both in quantity and in value. The clovers especially suffer, having less power than some of their competitors to take potash from the soil, and, as they diminish, weeds come in to take their place." Thus, from the above, farms which may be first expected to show deficiencies of potash are those on light land, while fields which are most likely to respond to added potash are those which are repeatedly cut for hay.

Top-dressing Trials with Potash.

One of the major activities of the Fields Division of the Department of Agriculture is the carrying-out of simple observational trials on pasture to determine the main plant-food deficiencies in various districts, and since 1924 approximately 700 trials have been laid down throughout the Dominion. These trials are simple in design and rely wholly upon the visible differences apparent at the time of the Instructor's visit, which takes place about every two or three months. Included in the treatments are potash alone, phosphate (either super or slag) plus potash, and phosphate plus lime plus potash. Potash is applied annually in the form of 30 per cent. salts at the rate of 2 cwt. per acre, phosphate in its various forms at 2 cwt. or 3 cwt. per acre, and lime as carbonate at 1 ton per acre in the first year, with 5 cwt. per year subsequently.

Potash alone has, given responses in only a very limited number of trials, and these have usually been apparent when the experiments were laid down on fields which were heavily phosphated previously. Occasionally, potash alone has proved detrimental to the general vigour of the sward, and in one trial in Poverty Bay the sward in the potash plot took on a most peculiar discoloured appearance, the grass assuming a brownish-purple colour and the clovers disappearing altogether. The addition of phosphate very largely counteracted this effect. In certain districts potash added to phosphate increases the production or improves the sward markedly as compared with phosphate alone. There is also a certain number of trials in which, although no appreciable effect is produced by the addition of potash to phosphate, marked results are obtained by the combination of potash with phosphate and lime. Bell(3) comments on this freely in his review of potash responses in Auckland Province.

Characteristics of Potash Effect.

In the subsequent remarks the effectiveness of potash refers to that brought about by 30 per cent. potash salts in addition to phosphate as compared with phosphate alone. The general effects of potash on

the sward described by Bell are typical of those in most trials where this material has given visible results. Firstly, there is an increase in growth of all the clovers present. Secondly, the white clover eliminates the annual species and covers bare-ground spaces: . Finally, the better grasses, if these were originally present, are improved as a result of the vigour of the white clover, forming a well-balanced sward of grass and white clover. This, in effect, is the same process of improvement wrought by phosphates in building up a sward after initial top-dressing. On a good sward the amount of growth is sometimes increased, and this is apparent when some of the trials are closed for hay. Almost invariably where there is a potash response a definite preference is shown to those particular plots by grazing animals. This palatability must not be confused with the partiality shown by stock to pasture immediately after it has been dressed with 30 per cent. potash salts or kainit, since the latter is largely due to the sodium chloride (present as impurity), which is particularly appetizing. The real ultimate palatability is probably associated with a higher potash content of the herbage as well as a greater clover content of the sward, and this takes place some time after application. Potash responses may be distinctly regional in their occurrence, sometimes they can be correlated with a definite soil type, in other cases climatic conditions play a large part, since heavier rainfall,conditions appear to exert some influence.

"POTASH-RESPONSE" DISTRICTS.

North Auckland.-Some good results from potash top-dressing have occurred on the peaty sands, on the red-brown soils derived from basalts, and on some of the mature podsols known as sandy gum lands. These types are scattered throughout the North Auckland Peninsula.

South *Auckland.*—Soil types similar to the North Auckland ones mentioned are found in the Manukau and Franklin Counties, and similar results have been obtained from potash except on the volcanic soils, 'where there is considerable variation in regard to response. In one or two experiments striking results have been obtained ; in others, apparently on the same soil type, the results have been negligible.

Waikato.-As the soil types of the Waipa County have been accurately mapped by the soil survey, it has been possible to lay down a number of trials on given types. So far results favourable to potash have been secured on three trials on the Horotiu sandy loam, one trial on Kaipaki sandy peat, and one trial on the Hamilton clay loam.

Waihi.—Potash responses in this district have probably. been more marked than in any other area surveyed, not only by the degree but also by the quickness with which they become apparent. Bell(3) considers that- -these -results- are confined to the sandy loams and do not occur on the alluvial soils. The rainfall in this district is exceptionally high.

Taranaki.—A large series of experiments laid down throughout Western Taranaki have indicated that potassic fertilizers give favourable responses generally. The latter do not seem to be correlated with any particular classes of the three main volcanic showers as demarked by Grange and Taylor (4). Those trials located in North Taranaki appeared to show responses very quickly. more, particularly in the high-rainfall

belt' close. to Mount Egmont. In South Taranaki the results from potash have not been so consistent, nor have they been so quickly apparent as in the more northerly trials; but in a few cases quite striking results have occurred in the second and third years of the experiments. Two grazing trials in which potash-treated fields were compared with those receiving no potash, both receiving phosphate, were laid down in Taranaki in 1934. So far, two applications of 30 per cent. potash have been made. In the first season increases in grazing-days of 10 per cent. and,23 per cent. respectively could be attributed to potash, while in 1935–36 the increases were in the order of 62 per cent. and 17 per cent. respectively. The improvement in the sward on the two potash areas has been consistent throughout the period over which the trials have been conducted.

Southland.—Some of the experiments in Southland have already been summarized by Tennent and Stuart(z), who reported that the number of trials indicating responses from potash was high in Eastern Southland, while a few very good results had been obtained in Western Southland. In the former district potash was most consistently effective in the Mataura Valley, where excellent results from its use as a top-dressing material have been recorded.

Raetihi.—Fairly definite results were secured in a few' trials in the Raetihi district, the soil of which: according, to Grange(b), is formed from a volcanic shower of andesite.

Other Districts.-Isolated instances where potash was effective occur in other districts, but either they are not substantiated by like results or sufficient trials have not been laid down to definitely refer to these areas in the same manner as the foregoing.

In the following districts only a small proportion of trials, has given visible results from potash, and, when apparent, they have been slight or spasmodic : Bay of Plenty, Poverty Bay, Hawke's Bay, Manawatu, Marlborough, Westland, Canterbury, and Otago. Results of trials in many of these districts have been published@), (7), (8), (g), and (10).

It must' be emphasized that since potash alone applied to a grassland sward has generally failed to show appreciable results, the effects quoted above are those from potash plus phosphate as compared with phosphate alone, or those from potash plus phosphate plus lime as compared with phosphate plus lime. Therefore,. if phosphate, with or without lime, gives marked results over no treatment, any extra impetus given to growth by the addition of potash may be difficult to see. On the other hand, if phosphate, with or without lime; produces little, change over no treatment, there is more chance of any extra improvement caused by potash being observed. In the latter case, however, it is considered that potash may be a major limiting factor, and it is the major limiting factors which these observational trials are designed to detect. The actual amount of improvement brought about by any of the treatments can only be measured by trials of 'a more refined nature, and it is hoped, ultimately, that these will follow when the main regions of fertilizer responses have been mapped out.

In regard to the different potassic fertilizers available, 30 per cent. potash salt has given slightly better results than its equivalent. in sulphate of potash or muriate of potash. Trials with varying 'quantities

of the former have indicated an appreciable superiority of 2 cwt. per acre over 1 cwt.; but applications of 3 cwt. per acre did not appear to be substantially better than 2 cwt. dressings.

Quality of Produce.

References to potash- manuring promoting quality" in the products of grassland are somewhat vague. In an experiment at Marton(11) Hudson and Doak reported that, while potash added' to phosphatic and nitrogenous fertilizers had produced only a slight dry-weight increase, the potash content of, the herbage from such plots was at all times higher than that from plots not receiving potash. These writers quote Woodman and Underwood(12), who state " there is no important reason for attempting to improve the potash content of the herbage by manurial treatment, since *untreated* herbage contains sufficient to supply the requirements of grazing animals." The function of potash in animal nutrition seems. to be obscure, and, in regard to nutrition, it does not appear of very great moment whether the dry matter contains 2 per cent. or 3 per cent. of potash (K_2O).

In supplying potassic fertilizers the farmer is chiefly concerned with yield-increase, firstly of grass and secondly of the live-stock product, and there is quite a difference of opinion relative to the factors correlating yield of grass and yield of animal product.

Potash in the Soil.

Estimations of available potash in the first 3 in. of soil do not suggest any correlation between the figures so obtained and the potash responses. In point of fact, Bell(3) quotes analyses showing a Waihi soil, which was particularly responsive, as having an available K_2O content of 0·098 in the first 3 in. Numerous soil-samples from Taranaki could, also be quoted to support the unreliability of soil analyses as a guide to manuring practice. There is a school of thought which supports " massive " applications of potash, or, in the words of Eckstein(13), " If a fertilizer experiment be laid down on a soil which tends to absorb potassium energetically, applications of potash may at first show no effect, not because the Soil. is rich in' potash but because the degree. of saturation of the soil colloids with respect to potassium is too low." Trials which have been. laid down some years, but which in the earlier stages showed no appreciable responses to potash, commenced to give results last season. It will be interesting to see whether. this is maintained in another year,: in view of Eckstein's hypothesis,. but;' on the other, hand, last season -was a particularly wet one, and the high rainfall 'may have been a factor contributing to a spasmodic improvement.

Summary of Present Knowledge.

(1) The use of potash alone for top-dressing pastures has proved in the main to be ineffective. In isolated cases good results have been obtained, but, conversely, in a few specific instances detrimental effects have been recorded.

(2) Certain districts enumerated appear to be definitely responsive to top-dressing with potash in conjunction with phosphates, or

phosphates and lime, and good results have been recorded in these localities. Such responses have been characterized by an increased content and vigour of clover in the sward. Thus white clover can be regarded as the index plant for soil-requirements of phosphates, lime, and potash.

(3) Evidence tends to show that the improvement of white-clover growth may be the main contributing factor in the increased palatability of the herbage which is often associated with such responses.

(4) Some of the best results have been obtained on pastures which had previously been cut for hay or silage frequently.

(5) Areas on which potash has been effective have several features in common : (*a*) They arc generally subject to high rainfall ; (b) the soils are mostly light in texture or have been well leached ; (c) in general the soils derived from andesite and basalt show more consistent responses than do those derived from rhyolite.

In conclusion, it should be pointed out that most of the trials carried out so far have been qualitative only, and that it is hoped to carry out more comprehensive experiments on areas showing the major potash responses. Nevertheless, the observational trials carried out have indicated that in certain districts potash can definitely be recommended. The data from the more detailed experiments, together with the general survey of fertilizer responses and the soil survey which is at present being carried out by officers of the Geological Survey, probably will add greatly to our knowledge of fertilizer deficiencies and their alleviation.

REFERENCES.

(1) HUDSON, A. W. : " Investigations into Pasture Production," Part I, Bull. 31, N.Z. Department of Scientific and Industrial Research.
(2) Russell, E. J. : " Artificial Fertilizers in Modern Agriculture."
(3) BELL, J. E. : " Potash Top-dressing of Auckland Pastures." (Unpublished paper.)
(4) GRANGE, L. I., and TAYLOR : " Reconnaissance Soil Map of Western Taranaki."
(5) TENNENT, R B., and STUART, A. : " Pasture Top-dressing in Otago and Southland." N.Z. *Jour. of Agric.*, February, 1934.
(6) GRANGE, L. 1. : " Volcanic-ash Showers," *N.Z. Jour. of Sci. & Tech.*, Vol. 12, No. 4.
(7) HUDSON, A. W., and MONTGOMERY, A. Y. : " Pasture Top-dressing in Canterbury." N.Z. *Jour. of Agric.*, October, 1930.
(8) MCGILLIVRAY, R., and ELLIOTT, A. G. : " Pasture Top-dressing in Marlborough." N.Z. *Jour. of Agric.*, September, 1932.
(9) MCCULLOCH, W. J. : " Pasture Top-dressing in Wellington and Southern Hawke's Bay." *N.Z.* Jour. *of Agric.*, February, 1933.
(10) MCGILLIVRAY, R., and STEVENSON, J. : " Pasture Top-dressing on West Coast, South Island." *N.Z. Jour. of Agric.*, October, 1934.
(11) HUDSON, A. W., and DOAK, B. W. : " Investigations *into* Pasture Production." Part III, Bull. 31, N.Z. Department of Scientific and Industrial Research.
(12) WOODMAN, H. E., and UNDERWOOD, E. J. : *Jour. of Agric. Sci.*, Vol. 22, Part I.
(13) ECKSTEIN, 0. : " Potash Research."

DISCUSSION.

(Follows next paper.)