SOME ASPECTS OF NITROGENOUS FERTILISERS IN RELATION TO PLANT TOXICITY.

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Nitrogen is an essential plant food and it is particularly important that further knowledge of the correct method and time of making it available to pasture. plants should be obtained in these days when a steady high production per acre at low cost is desired.

Nitrogen applied in various forms and under differing conditions has produced definite differences in the growth of pasture plants. Certain forms have proved definitely "toxic" to some species while other forms have encouraged the growth of all plants in the pasture association.

Knowledge of the action of different forms of the nitrogenous fertilisers on pasture species is valuable, if not essential, when correct balance of the grasses and clovers is required. This knowledge is' -equally valuable in the maintenance of playing greens where weed and clover control is essential.

The term "toxic" is applied to those fertilisers which, when applied, even at moderately light rates, of from one to two cwt. per acre, cause a burning of the foliage or retard the growth of. the plant through some complex action between the soil and the plant.

"Non-toxic" nitrogenous fertilisers are those which stimulate the growth of all pasture plants.

These so-called "toxic" fertilisers are more severe on some plants such as clovers and weeds than they are on grasses.

The endeavour in this paper is to gather information regarding this "toxicity" and to explain some of the possibilities of increasing production without causing those bad effects which are generally associated with the use of certain nitrogenous fertilisers.

Before dealing with these so-called "toxic" nitrogenous fertilisers some reference to other commercial nitrogenous fertilisers should be made for comparative purposes.

Dried blood is perhaps one of the oldest Nitrogenous fertilisers of commerce. It is slow in its action and comparatively low in nitrogen content. It is "non-toxic" and is an organic fertiliser.

Nitro-chalk is a "non-toxic" inorganic, quickly acting fertiliser which would be valuable for topdressing pastures requiring nitrogen were it not for the fact that in its present commercial form it is difficult to distribute.

Calcium cyanamide is also an inorganic nitrogenous fertiliser but has slight "toxic" effects on pasture plants. This "toxicity" however is only temporary and should not be considered so serious as the cumulative and permanent "toxic" effects of certain other fertilisers.

Nitrate of Soda is a quickly acting inorganic fertiliser of the "non-toxic" form. It is one of the most commonly used nitrogenous fertilisers but its use for pasture top-dressing has been limited on account of the difficulty of even distribution through mechanical distributors. The new synthetic nitrate of soda in granulated form can be more evenly distributed than the older crystalline type.

The so-called "toxic" nitrogenous fertilisers are those in which the nitrogen is combined in ammoniacal form as Ammonium phosphate and Ammonium sulphate. Ammonium phosphates of differing nitrogen to phosphate ratios have been manufactured and these fertilisers may have gained popularity for pasture topdressing on account of their concentrated form were it not for the fact that the small crystals unite to form large hard lumps which are difficult to crush fine enough to permit of even distribution.

Had Ammonium phosphates been used to any great extent deleterious effects similar to those caused by sulphate of ammonia may have been noticed more frequently; Sulphate of Ammonia is the most common inorganic nitrogenous fertiliser used on pastures. It is used either alone or combined with superphosphate as ammoniated super.

Sulphate of ammonia had been tried on experimental plots to determine its value and effect in comparison with other nitrogenous fertilisers. The results of the experiments in many instances have not been in favour of Sulphate of ammonia which in certain cases has produced an adverse effect on pastures. The reason for this ultimate adverse effect has not been satisfactorily explained, but it is hoped that the details set out in subsequent paragraphs may reveal some possible explanations.

The data upon which the reasoning is based have been obtained largely from the greenkeeping research work which has been conducted in New Zealand during the last four years. Observations on pasture and greenkeeping research plot trials have been correlated with results obtained in farm practice and these, together with some knowledge of the vast amount of research work which has been conducted in other countries, makes possible a better understanding of the merits and demerits of ammoniacal nitrogenous fertilisers.

Table 1 will give some indication of the effect of Sulphate of ammonia and other nitrogenous fertilisers on a closely mown turf.

The analyses* shown were made on the greenkeeping research plots where weed and clover control and suppression was desired.

Table 1.

Plot	A.	B.	C.	D.	E.	F.
Bare ground	15	6	4	1	6	7
Brown top	43.2	37.0	28.9	38.6	43.9	37.9
Chewings fescue	35.1	28.6	26.6	25.0	38.8	35.1
Clovers (annual and perennial)	3.0	28.6	30.8	29.6	9.2	14.3
Weeds	3.7	5.8	9.7	5.8	2.1	5.7
	100.0	100.0	100.0	100.0	100.0	100.0

* Point method of pasture analysis.
Levy and Madden, N.Z. Journal of Agriculture, May, 1933.

Plot A has been topdressed every 3 months over a period of three years with Sulphate of ammonia only, at the rate of $1\frac{1}{2}$ cwt. per acre per annum, i.e.., 18 cwt.. over the duration of the trial,

Plot B. Nitrophoska, a complete fertiliser, containing 16.5% Nitrogen, 16.5% Phosphate, 20% Potash, was applied at the rate of $7\frac{1}{2}$ cwt.. per acre per annum at three monthly intervals.

Plot C. Leunaphos, a fertiliser containing 20% Nitrogen and 20% Phosphate was applied at 6 cwt. per acre per annum.

Plot D.. Topdressed with a complete fertiliser mix'ture, Nitrate of soda 8 cwt., Superphosphate 4 cwt., and 30% Potash, 4 cwt. per acre per annum.

Plot E. Topdressed with a complete fertiliser mixture. Sulphate of ammonia 6 cwt., Superphosphate 4 cwt., and 30% Potash, 4 cwt. per acre per annum.

Plot F. Topdressed with a complete fertiliser as for E . but received in addition 35 cubic yards of compost per acre per year. This acts as a buffer to the toxic fertilisers and provides organic matter for the soil.

Where Ammoniacal nitrogen has been used, plots A and E, there has been a definite suppression of weeds and clovers.

Nitrate nitrogen, plots B and D, has stimulated clovers to an extent that they have created a smother on the grasses.

Leunaphos, Plot C, has produced a similar turf to that on the Nitrate of soda and Nitrophoska plots.

Leunaphos which is "non-toxic" is supposed to contain 60% of Sulphate of ammonia. The "non-toxic" effect is attributed to the granulated form in which. Leunaphos is made. To test this theory Leunaphos and Ammonium phosphate were each finely powdered and applied to the turf, Ammonium phosphate browned the grass slightly and killed a fairly large percentage of weeds and clovers, while Leunaphos produced no such effect. The "non-toxic" property of Leunaphos therefore may be attributable to some factor other than granulation, and support is lent to this supposition by reason of the fact that when it is mixed with iron sulphate, the latter i.s converted to an iron oxide. The conversion of iron sulphate to iron oxide has not been noticed when other nitrogenous fertilisers have been mixed with iron sulphate and this probably indicates that all the nitrogen of Leunaphos is not necessarily present in ammoniacal form.

Past experience indicates that only those fertilisers which contain ammoniacal nitrogen have a "toxic" effect on pasture. plants and yet there are many instances where these have been highly beneficial to both pastures . and playing greens. This suggests that the deleterious effects result, not from the use, but from the misuse of ammoniacal fertilisers.

Sulphate of ammonia increases soil acidity and this soil condition retards bacterial development.. Soil bacteria are necessary to convert ammonia to a nitrate, which until recent years, was considered to be the only form in which plants could assimilate their nitrogen, but more recent investigations disclose the fact that certain plants can absorb nitrogen in either the nitrate or ammonia cal form.

To remedy or to prevent the apparent toxic effect of Sulphate of ammonia in the past lime has been used. This treatment has reduced soil acidity and this in turn has favoured bacterial development again.. Lime has., therefore, been valuable in alleviating the deleterious effects of ammoniacal fertilisers but it has not been entirely satisfactory on account of the losses of nitrogen it has caused. Through the conversion of the ammonia into a nitrate much of this has possibly been leached from the soil., while had no such conversion taken place the ammonia would have been retained by the soil.

Overseas research workers, Blackman, Breal, Prianishnikow, Smirnow, Mothes, Onslow, Ruhland, and Wetzel, and others, have conducted most extensive trials with regard to the responses of various types of plants to different nitrogenous fertilisers.

To quote or refer specifically to these various authorities seems unnecessary in this paper but summarising some of the articles on the subject should suffice.

'The salient features of the articles are': Plants that belong to the botanical order gramineae which embraces grasses, store reserves of sugars within their tissues, but plants of other botanical orders, with exceptions, store most of their carbohydrate reserves in a starch form. Ammonium ions on absorbtion combine with the sugar reserves of the plant to form asparagine, but if the sugar reserves are insufficient., the ammonium ions accumulate to a toxic extent.. The relative uptake by the plant of nitrate or ammonium ions is dependent to some extent on the acidity of the soil, the maximum absorbtion of ammonium ions occurring in slightly acid soils.

From what has been stated in the preceding paragraphs, therefore, it is presumed that by the using of Sulphate of ammonia the soil acidity is increased, thus necessitating that plants shall absorb a large percentage of their nitrogen requirements in ammoniacal form.

The value of ammoniacal nitrogenous fertilisers is dependent very largely upon the amount of reserve sugars which the plant has available for conversion, by the ammonium ions, to asparagine .

It appears that the formation of asporagine is essential and that this substance is the starting point of protein synthesis. If this is correct it is quite obvious that to force the absorbtion of Ammonium ions not only depletes the sugar reserves but it does so at such a rate that protein synthesis is checked also.

Plants other than grasses, that is, those which do not have abundant sugar reserves, should be more readily affected by the absorbtion of an excess of ammonium ions. In practice it is found that this is so generally, as instanced by the fact that weeds and clovers can be controlled easily in lawns by heavy dressings of sulphste of ammonia. When however, this fertiliser is applied heavily and frequently to closely mown turf, the health of the grasses is also greatly impaired despite the fact that grasses store their 'carbohydrate reserves as sugars and should therefore be able to tolerate heavy dressings of sulphate of ammonia. This applies frequently in pastures also but in these circumstances the weakening of the grasses is invariably attributed to a reduction in the clover content of the sward. This aspect cannot be overlooked for no-doubt the reduction in clover content must materially affect the nitrate content of the soil and this in turn would reflect unfavoursbly on the grasses after the nitrogen from the Sulphate of ammonia has been exhausted.

Prevention of this "toxic" effeot of Sulphate of ammonia is possible to some extent by liming to maintain the soil in a neutral or very slight acid oondition. This will prevent the quick uptake of ammonium ions by the plants and it will permit bacterial activity and the con-- version of ammonia to a nitrate.

Possibly the maintenance. of large sugar reserves in all plants is still more important and this is easier to accomplish if the plants, i.e., grasses and clovers both, are liberally supplied with all necessary mineral foods to ensure healthy growth.

As sugar reserves are apparently essential to prevent the "toxic" effect of sulphate of ammonia it seems perfectly sound to recommend the spelling of pastures from close grazing to permit a fair amount of leaf growth prior to applying the fertiliser.

An outstanding instance of this was brought to my notice some months ago. A farmer temporarily fenced off a portion of a paddock in order to concentrate a few calves on a small area. Shortly afterwards the whole paddock including the closely grazed portion was topdressed with Ammonia-ted super at 3 cwt. per acre. The response to the fertiliser of the ungrazed pasture was a striking contrast to the closely grazed area where there was not only no response but a definite detrimental effect due probably to the "toxic" action of the ammonia on the plants which had no storage capacity for reserves of sugars.

The same principle must apply in the management of playing greens which are being defoliated regularly by the lawn mower.

The use of Sulphate of ammonia should not be condemned but the type and condition of the turf upon which it is to be used and the manner and time of its application should be investigated for eaoh set of climatic and environmental conditions.

In conclusion Nitrogenous fertilisers may be described as "toxic" and "non-toxic". The "non-toxic" forms such as Cried blood, Nitrate of soda, and Nitro-chalk may be used judiciously without fear of any detrimental effects to the pastures through either contact or absorbtion. "Toxic" forms such as sulphate of ammonia can, under certain conditions, be injurious to pasture plants, but in practice these fertilisers may be applied to soils that have been previously limed to control acidity, and to soils that are well supplied with organic molter, which seems to act as a buffer to the "toxic" principle. In addition to these facts the application of the fertiliser to pastures which are leafy, rather then to those which are closely graze&appears sound if the theory of the sugar reserves rendering the ammonia innocuous is correct.
