The Toxicity of North African Phosphate and Superphosphate to Milking Cows

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I... INTRODUCTION.

The first reported occurrence of poisoning of livestock from the ingestion of phosphatic fertilisers in New Zealnad was in the Manawatu district in the autumn of 1950, when Mr. I. M. Macfarlane, M.R.C.V.S., of Palmerston North, reported that several dairy herds had suffered severe diarrhoea accompanied by a sudden and lasting reduction in butterfat production of about 50 per cent., with a few abortions and one death in a cow which showed symptoms of abdominal pain and bloody diarrhoea. The trouble began within a few days of the herds being grazed exclusively on pastures freshly top-dressed with North African ground rock phosphate, no rain having fallen since top-dressing was carried out.

No reports have been found of similar trouble being experienced with superphosphate or other fertilisers in New Zealand.

II... EXPERIMENTAL.

(a) **Preliminary Dosing Trials**: Three dry and three milking cows were dosed 0.5lb. North African phosphate once daily for five days, without apparent ill-effect on health or milk yield.

(b) **Preliminary Top-Dressing Trials**: Three groups of three milking cows were grazed for seven days on 10-inch high Italian ryegrass in one acre paddocks treated as follows:—

1. 5cwt. North African phosphate (N.A.P.).
2. 5cwt. Superphosphate.
3. No treatment.

Top-dressing was applied in the early morning while the pasture was wet with dew, so as to obtain the maximum adhesion of the fertilisers to the herbage. A direct-drop type of distributor was used, running to within about 30 inches of the fences, runs being overlapped about 12 inches. No rain fell until the fourth day of the trial, when there was a fall of 100 points.

For three days the cows on the two top-dressed paddocks grazed only on the strips along the fences and in the corners over which the distributor had not passed, and in the superphosphate paddock, also on thin crescent-shaped strips near the corners which had been missed in turning. The untop-dressed paddock was grazed evenly all over. By the third day all six cows on the top-dressed paddocks were scouring, particularly those on the North African phosphate paddock. An average drop in milk production of 40 per cent. in the N.A.P. cows and 10 per cent. in the superphosphate cows had occurred by the third day. After the rain fell on the fourth day, production rose again and scouring gradually ceased.

The cows on N.A.P. then began grazing patches of the top-dressed area of the paddock very short, but up to the seventh day still only enlarged these patches. From the fourth day the cows on the superphosphate began grazing fairly generally, avoiding only the strips where overlapping of runs of the distributor had applied a double dressing.

Weight losses in the cows on the top-dressed paddocks were only temporary and of negligible amount, while the control cows showed slight but equally negligible gains in weight. Milk production had returned to normal one day after returning to normal pasture in the superphosphate group, and after seven days in the N.A.P. group. Milk production in the control group remained steady throughout the period of the trial.

Although the herbage eaten in the first three days on the top-dressed paddocks had not been covered directly by the distributor, the results of the next two experiments suggest that there must have been sufficient fertiliser carried to it by the wind to have been responsible for the scouring and reduction in milk yield in the cows which consumed it. Similar effects have been produced by severe under-feeding in other experiments at Wallaceville, but in such cases body-weight losses have been very considerable.

(c) **Second Top-dressing Trials:** Three groups of ten cows were grazed for seven days on 3-inch long ryegrass-clover pastures treated as follows:—

1. 3cwt. N.A.P. per acre.
2. 3cwt. Superphosphate per acre.
3. No treatment.

The cows were run on three adjacent sets of day and night paddocks of three and two acres in area. Top-dressing was applied in the early morning while the pasture was wet with dew, and, in addition, the fence-lines and corners of the paddocks were dressed by hand-broadcasting so as to leave no untop-dressed herbage available for the cows in groups 1 and 2. Pasture samples in all paddocks were taken for phosphate determination before and just after top-dressing and at intervals during the following week. No rain fell until the sixth day of the trial, when there was a fall of 100 points.

Grazing time between 7 a.m. and 8 p.m. was recorded for each of the thirty cows on alternate days from the day before top-dressing until the first day the cows were all grazed together on normal pastures. The control group's average grazing time increased steadily from 7.6 to 8.5 hours daily during the week on the experimental paddocks, as would be expected owing to the feed becoming shorter. In contrast, the N.A.P. group's average fell steadily from 7.25 to 7.0 hours daily throughout the week on top-dressed pasture. The cows on superphosphate also decreased their grazing time from 7.4 to 7.2 hours daily, throughout the week. These decreases may have been due either to loss of appetite or unpalatability of the herbage contaminated with the fertilisers.

As in the preliminary top-dressing trial, the cows on top-dressed pastures scoured, those on N.A.P. most profusely, and milk production fell 40 per cent. by the third day in the N.A.P. group and 15 per cent. in the superphosphate group.

On the morning of the third day two cows in the N.A.P. group scarcely grazed at all, and gave practicially no milk at evening milking. They appeared weak and were somewhat unsteady in gait, and it was deemed advisable to take them off the top-dressed pasture. They ate fairly well on normal pasture that evening, and were grazing normally two days later. Reduction in milk yield in one of these cows was from 53lb. to 11lb. The only cow on N.A.P. whose production was not affected was a very poor-producing heifer yielding only 4lb. milk daily.

There were slightly greater temporary losses in body weight in the N.A.P. cows in this trial than in the preliminary trial, suggesting that reduction in grazing time may have actually lowered food intake. No

indication of selective grazing could be detected in the N.A.P. paddocks. Definite evidence of selective grazing was seen in the superphosphate group's day-paddock, which was younger pasture than the others, and richer in clover. Patches on which heavy fertiliser contamination was visible were completely avoided in grazing.

Pasture analyses showed that 25lb. of dry matter cut at random over the paddocks contained about 1lb. N.A.P., and 2lb. superphosphate on the day of top-dressing . Assuming a normal grazing intake, a 1000lb. cow might then consume these quantities of the various fertilisers, also assuming the absence of selective grazing. The higher quantity of fertiliser on the superphosphate dressed paddocks was presumably due to the greater amount of clover in the day-paddock so treated, the broad, horizontal leaves of the clover holding many large granules of the superphosphate. The North African phosphate, being a fine powder, would be more evenly and thinly distributed on all plants alike.

(d) **Decontamination Trials** were conducted in the late autumn of 1951, to determine the amount and intensity of rainfall required to wash a pasture sufficiently clean to render it safe for grazing by milking cows after top-dressing with 3cwt. N.A.P. per acre.

A series of paddocks were top-dressed as in the second top-dressing trial, groups of three cows being admitted to these paddocks at weekly intervals. Thus, paddocks were first grazed (a) immediately, (b) one week, (c) two weeks, and (d) three weeks after top-dressing. Group A suffered a 30 per cent. drop in production compared with the control group in the first three days. During this time there had been a fall of 33 points of rain, mostly on the first day. This group remained on its paddocks for three and a-half weeks, but did not recover in spite of later good falls of rain. One cow dried off in 14 days.

Group B declined 50 per cent. in production in the first few days, although a total of 33 points of rain had fallen before they started. All three had dried off after nine days.

Group C started after the rainfall since top-dressing had totalled 100 points, and while one of the three cows went dry, the other two kept up their production for two weeks.

A further fall of 150 points, making a total of 250 points, had occurred by the time the fourth group started grazing the top-dressed paddocks, and their milk production increased by 10 per cent. in the first three days. There was a good growth of fresh feed on these paddocks at the time the cows were admitted.

(e) **Second Dosing Trials:** In order to determine the cause of the toxicity in the above trials, dosing trials were set up as shown in the following table:—

Substance Dosed:	No. of Cows:	Twice-Daily Dose:	Days Dosed:	Milk Yield Decline:	Scouring:
1. North African Phosphate	6	0.5 lb.	6	40%	Severe
2. Superphosphate	4	1.0 lb.	5	40%	Severe
3. Powdered Greywacke Rock	3	0.5 lb.	5	Nil	Nil
4. Precipitated Tricalcic Phosphate	3	0.5 lb.	5	15%	Nil
5. Purgatives:					
(a) Magnesium sulphate	4	0.5 lb.	2	Nil	Nil
followed by		0.75 lb.	1	Nil	Nil
followed by		1.0 lb.	4	15%	Nil
followed by					
(b) Raw Linseed Oil		1.0 pint	2	15%	Nil
6. No Treatment	12	nil	6	Nil	Nil

The dosing was by drenching, twice daily, after milking.

The quantities of fertilisers dosed were based on the estimated possible intake on top-dressed pastures from the analyses carried out on the pastures in the second top-dressing experiment. In both the N.A.P. and superphosphate-dosed groups there was profuse scouring and also a drop in milk production of 40 per cent. by the third day in both groups. The superphosphate-dosed cows also averaged a loss of 80lb. in bodyweight, which was not recovered until 10 days after dosing was stopped.

Greywacke rock was dosed to test the effect of particulate mineral matter on the cows, but no effect on milk yield or bodyweight was produced.

Precipitated tricalcic phosphate was dosed to determine the effect of an equivalent amount of phosphate in a fairly pure form to that contained in the quantity of N.A.P. dosed. Purgatives were given with the object of determining to what extent the effects on milk production of the fertilisers were due simply to purgation. Both the tricalcic phosphate and the purgative groups showed temporary slight falls in milk yield, reaching a maximum of 15 per cent., but no scouring occurred in either group, nor were weight losses appreciable.

III. DISCUSSION.

The toxic principle has not yet been isolated or identified chemically from North African phosphate, but it seems clear that the superphosphate used in these trials, which is manufactured from Nauru and Ocean Islands rock phosphate, contains at least some of this toxic factor.

Our top-dressing and dosing trials would indicate that level of intake is the determining factor in whether or not toxic symptoms are shown by livestock. Factors governing intake would include: (a) method of top-dressing—complete coverage of a whole farm so as to leave no alternative to consuming top-dressed pasture would be more dangerous than where only a few paddocks at a time were treated; (b) wet conditions at the time of top-dressing followed by a dry period would produce greater contamination of the herbage than dry conditions due to adhesion of fertiliser to moisture droplets on the leaves; (c) length of pasture—long grass, even if lightly top-dressed, as in the fence-line strips in our preliminary trial would retain more fertiliser than short grass, which would let more fall through to the ground; (d) rate of top-dressing—assuming that other conditions were equal, higher rates of top-dressing would result in greater contamination; (e) the selective grazing ability of the animal—this point was well illustrated by the grazing pattern in the preliminary top-dressing trial, and in the superphosphate dosing as compared with superphosphate top-dressing trials. In the top-dressing trial, although pasture samples cut at random showed a possible daily intake of superphosphate of 2lb. per cow, the production and bodyweight losses in the top-dressing trial were less than half the losses suffered when 2lb. was dosed; (f) rainfall incidence—probably the most important factor, since a good fall of rain between top-dressing and allowing cows on to top-dressed pasture would remove the risk to the cows.

A problem of major interest arising from the results of this investigation is why there has been so little reported trouble from fertiliser poisoning, in view of the widespread use of top-dressing in New Zealand in the past. Probably the main cause is that bulk distribution top-dressing by which whole farms are treated by contractors in a few days, has in some areas recently replaced the previous practice of the farmer himself treating a few paddocks at a time over the course of several weeks.

It would seem possible that in many cases the effects of superphosphate poisoning would not be noticed, and had not the trouble been experienced with North African phosphate, which prompted us to examine superphosphate, the latter fertiliser would still be unsuspected as a cause of loss of production.

Although North African phosphate has been in use for many years in New Zealand, its main use has been in high rainfall areas having acid soils, for which it is more particularly recommended. It may have been only the combination of a shortage of superphosphate and an abundance of money which resulted in its use in drier districts in 1950, since even then it was considerably dearer than superphosphate.

Our attempts to determine the amount of rainfall necessary to cleanse a pasture of North African phosphate were unfortunately not entirely conclusive. Firstly, the cows were in late lactation, and with the small groups then available, and individual differences in rate of natural drying off, the effects of the fertiliser were not quite clear-cut. We did confirm the field experience reported by Mr. Macfarlane, that th drop in production in cows in late lactation from North African phosphate poisoning was permanent, whereas our earlier trials, which were conducted in the spring and early summer, resulted in only temporary production decreases. It can be said, however, pending repetition of the decontamination trials under more favourable conditions, that under the conditions of our trials, more than 33 points, and probably between 100 and 150 points of rain are needed between top-dressing and grazing, for safety. It should be emphasised that this applies only when top-dressing has been applied to wet pasture, to obtain maximum "stick," and that it applies only to North African phosphate, which, being finely ground, has a greater "stickability" than the granulated superphosphate commonly used. Under dry top-dressing conditions, probably much less rainfall would wash off North African phosphate to safe levels, and less still would remove superphosphate.

IV. CONCLUSIONS.

The risk of toxic effects from grazing pastures after top-dressing with North African phosphate and superphosphate may be reduced or obviated by (a) not top-dressing damp herbage, (b) awaiting a good fall of rain before putting stock on to recently-topdressed pastures, (c) top-dressing after a pasture has been grazed short so that most of the fertiliser falls to the ground, and (d) where bulk distribution methods are used, top-dressing about half the farm and grazing only the untop-dressed half until a good fall of rain occurs, then top-dressing the remainder after the earlier top-dressed half is proved to be safe.

Discussion

Dr. STEWART: Was any account taken of the fat content of the milk?

Mr. Swan: Fat content was determined on some of the cows in the second top-dressing experiment, and in these cows the fat content rose in those on N.A.P., compensating to a slight degree for the fall in milk yield. In the superphosphate group, on the other hand, there was no change so that the fat yield fell in proportion to the milk yield.

Mr. RINEY: As daylight grazing times only were taken, might there not be differences in the amount of grazing done at night?

Mr. SWAN: Daylight grazing times have limited value, but that was the best we could do with the labour available.

Mr. SEARS: In the superphosphate dosing trial, dosing did affect their bodyweight. What was the reason for this?

Mr. SWAN: Grazing time was not studied in the dosing trials, so that body-weight losses were not accounted for.

Mr. WOODCOCK: As N.A.P. and super both contain fluorine, might not this be the toxic factor?

Mr. McINTOSH: The fluorine would be removed during the preparation of superphosphate. This work is not an indictment of N.A.P. as the trials were designed to ensure maximum intake of fertiliser.