MAGNESIUM DEFICIENCY IN PASTURES

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A major break through in plant nutrition work occurred in 1958, when G. M. Will, of the Forest Research Institute, Whakarewarewa, Rotorua, clearly showed that the yellow stunted growth in seedling trees could be quickly corrected by the application of magnesium. This showed that the nursery soil was deficient in magnesium for tree growth; the burning question was, is this soil so deficient in available magnesium that a response will be obtained from an application to pasture plants? The answer was a definite yes, and for the first time we had a pasture trial giving significant responses to applied magnesium.

I used the collective term "we" to mean not only all those associated with this particular investigation, but also to include the farming industry of New Zealand as a whole. Clearly the individual farmer has the most to gain from this and similar experimental work on which sound advisory work is based. At last under our own conditions we were able to establish firstly the critical level for magnesium in pasture plants and secondly the level of magnesium in the soil below which a response to applied magnesium could be expected.

I am no scientist; it was just my good fortune to be associated with the interesting field work involved and I would here like to pay tribute to those who so painstakingly analysed in detail the many pasture and soil samples from this investigation. Plant analyses were carried out (by K. J. McNaught and staff of the laboratory at Rukuhia Soil Research Station, Hamilton) on white clover, red clover, and grasses with the levels of seven different elements: nitrogen, phosphorus, potassium, sodium, magnesium, calcium, and manganese being determined on over 400 individual samples. Soil analysis was carried out on over 70 samples. I do not propose to cloud this paper with all sorts of analytical data, as this would be better presented by those actually doing the work. I will merely present a summary of the results. I hope to present to you a graphic account of the trial, its progress, and the conclusions to be gained from it.

DETAILS OF INVESTIGATIONS

Location

This particular trial was sited at the nursery area close to the Kaingaroa forest headquarters some 30 miles from Rotorua. The elevation is 1,800 ft.

Soil Type

The soil type has been classified (by C. G. Vucetich, Soil Bureau, Department of Scientific and Industrial Research) as being derived from the Kaharoa ash and is termed Te Rere sand. Typical profile of this Te Rere sand shows:

5 in. of black friable sand with very soft fine crumb structure;
6 in. of pale grey weakly compact sand with faint fine reddish-yellow mottles;
8 in. white loose pumice gravel with thin bands of compact sand;
on brown friable silty sand merging to yellow sand (Taupo ash).

The profile is remarkably constant and the soil type extends to some 3,370 acres with in addition the Te Rere shallow sand (6-12 in. Kaharoa ash on Taupo ash) extending to 6,710 acres and Te Rere very shallow sand (3-6 in. Kaharoa ash on Taupo ash) extending to a further 5,810 acres, a total of about 16,000 acres,

The soil is free draining, but has the ability to retain a certain amount of moisture during droughty weather. In spite of the well distributed rainfall the district does suffer from drought, accentuated by hot drying winds in summer.

Weather

A fairly rigorous climate is experienced in the area.

Full rainfall data are given in the table on page 158, but in 1959 the total rainfall was 50.54 in. on 130 days, in 1960 62.83 in. on 148 days, in 1961 50.02 in. on 130 days, and in 1962 to the end of September 67 in. on 133 days.

The area is subjected to relatively severe winter conditions. One of the lowest temperatures recorded was in July 1960, the reading being 13 degrees F. The number of frosts annually is fairly high (consistently about 90). Apart from that it is a pleasant situation to live in.

History

The whole area had been cultivated out of virgin country in 1952. After lupins a crop of *Pinus radiata* seedlings was planted. A similar pattern followed over the years with a total of three crops of tree seedlings being taken before ploughing in February 1959, when it was sown to grass.

Seeds Mixture

As the area was an unknown quantity as regards pasture establishment, 1 tried to cover most conditions by broadcasting the following mixture:

	lb
Perennial ryegrass	20
Cocksfoot	7
Crested dogstail	1
Montgomery red clover . .	2
Cowgrass	2
White clover	2
Mt. Barker sub clover	2
Total	36

A basal dressing of 6 cwt per acre of superphosphate was applied.

Magnesium Application

Magnesium treatments were superimposed in November 1959 and comprised two rates of magnesium crossed with two rates of potash. Materials used were magnesium sulphate (Epsom-salt) and muriate of potash.

Treatments

1	Potash 2 cwt per acre.
2	Potash 2 cwt + magnesium sulphate 2 cwt.
3	Potash 2 cwt + magnesium sulphate 4 cwt.
4	Potash 4 cwt.
5	Potash 4 cwt + magnesium sulphate 2 cwt.
6	Potash 4 cwt + magnesium sulphate 4 cwt.

On left poor clover growth and low total production resulting from application of muriate of potash. On right vigorous healthy clover and grass growth resulting from application of magnesium sulphate in addition to potash.

Four replications were laid down with lime at 1 ton per acre on two replications. Owing to *some* areas of bare ground showing up, the area was surface sown at the same time as this topdressing with the original seeds mixture at half rate.

Growth came away vigorously, and by late February 1960 clear-cut responses to the magnesium treatment were noted. In addition it was possible to observe the depressing effect caused by the heavy application of potash alone. This feature continues to be evident, the main difference being in pasture composition, actual yield from 2 cwt of potash alone and 4 cwt of potash alone being about equal.

Cutting and Yields

Mowing commenced when there was adequate growth with the clippings being discarded, but the plot yields were only noted from October 1960 onwards. It is interesting to note that the yield data confirmed the visual observations made earlier, the summarised yields for the initial cut being:

	Lb dry matter per acre
No lime	1,060
1 ton of lime	1,300
2 cwt of potash	1,250
4 cwt of potash	1,110
No magnesium	850
2 cwt of magnesium sulphate	1,360
4 cwt of magnesium sulphate	1,330

Since that time cuts have been taken at fairly regular intervals.

Summary of Yield Data

A brief summary of the yield data follows. (Yield in pounds of dry matter per acre. The first season was from October 1960 to June 1961, and the second season from October 1961 to June 1962.)

Rates of Magnesium Sulphate

	None	2 cwt	% increase	4cwt	% increase
1st year	5,590	7,870	141	8,000	143
2nd year	4,080	6,730	165	6,310	155

Averaged out over the two seasons the 2 cwt of magnesium sulphate resulted in a 5 1 per cent increase in dry matter produced, with the 4 cwt rate giving an increase of 48 per cent.

Topdressing Applied

The initial 6 cwt of superphosphate was followed by an additional 6 cwt at the time of applying the magnesium treatments, with the re-application of lime where appropriate in

November 1959. The re-topdressing at original rates was also carried out in October 1960; however, in October 1961 only the basal application of 6 cwt of superphosphate was given and the potash application was amended to be 0 and 2 cwt per acre in place of the former 2 and 4 cwt, as the potash level had risen satisfactorily. The object of having the two rates of potash would be defeated if both rates became excessive. Lime application was repeated. No further magnesium was applied. This was an endeavour to find the residual effect of the previous applications. DDT was applied to the entire area.

By June 1962 it was clear that plots which had received magnesium in the early stages were declining in production and showing visual symptoms of magnesium deficiency. At the same time these plots were still far superior to the no-magnesium plots and in addition had a far superior botanical composition and superior sward.

Soil Analysis

The soil analyses taken before laying down the trial showed the following quick test levels:

Depth in.	pH	Ca	K	P	Mg (m.e. %)
0–1½	5.0	0	3	2	0.07
14-3	4.8	0	3	2	0.07
3-6	4.7	0	2	2	0.07

The magnesium level was extremely low.

Before the re-topdressing of all treatments in October 1960 all plots were sampled at O-3 in. depths with further selected samples 3-6 in. taken from the no-magnesium and high-magnesium plots.

Statistical examination of these samples gave the following results :

	pH	K	P	Mg
No lime ...	5.4a	5.3a	7.8a	1.60a
1 ton lime	5.8a	5.8a	12.9a	1.82a
2 cwt potash	5.6a	5.1bB	10.8a	1.75a
4 cwt potash	5.6a	6.0aA	9.9a	1.68a
No magnesium	5.6a	5.4a	11.8a	1.46bB
2 cwt magnesium sulphate	5.6a	5.8a	8.8a	1.74aAB
4 cwt magnesium sulphate	5.6a	5.5a	10.6a	1.94aA

These results showed an increase, as would be anticipated, in the potash and magnesium levels where the corresponding treatments have been applied. With only two replications the comparison of lime v. no lime is not measured precisely and in no case did it reach significance.

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The 3–6 in. subsoil samples indicated that there was no evidence of downward movement of either magnesium or calcium.

By June 1961 the full effect of the applications of phosphate and potash were showing up. The average of the samples from unlimed plots showed with quick-test figures:

Treatment	Depth	pH	Ca	K	P	Mg
0 Mg	O-3 in.	5.3	2	8	11	2.6
+ Mg	O-3 in.	5.3	2	9	11	6.9

The rapid magnesium test involves a two minute extraction of 4 gm of soil with 20 ml of neutral ammonium acetate, and the result can be converted to m.e. per cent by dividing by 15 for pumice soils.

As a result of the evidence from this trial, backed up by a similar trial at Whakarewarewa (conducted by C. R. Taylor, Instructor in Agriculture, Rotorua), K. J. McNaught, Rukuhia Soil Research Station, was able to estimate that the soil level at which pastures respond to magnesium lies in the range 0.10-0.15 m.e. per cent exchangeable magnesium.

Residual Effect

By June 1962 the magnesium levels on selected plots were:

Plot No.	Treatment	pH	Ca	K	P	Mg	Mg (m.e. %)
2	K4 + lime	6.3	6	3	15	1.4	.09
6	Mg4K4 + lime	6.2	5	2	12	2.6	.17
18	Mg4K4 + lime	6.4	5	4	14	2.4	.16
9	K4	5.6	2	5	12	1.6	.11
22	K4	5.6	2	5	12	1.1	.07
23	Mg4K4	5.5	2	3	8	1.9	.13

This showed low levels for magnesium and clearly indicated that in spite of heavy initial application of Epsom-salt, there was little carry-over effect, and that annual application would be required for optimum plant growth.

Plank Analysis

Without going into the full details I could mention some very interesting results of the plant analyses,

There was an indication of higher nitrogen level in grasses from the plus-magnesium plots. Analyses suggest that this was due to the release of nitrogen from the associated clovers, which were growing much more vigorously in these plots.

For samples taken in June 1960 the mean magnesium levels were:

	No magnesium	Plus magnesium
Grasses	.08% Mg	.11% Mg
White Clover	.11% Mg	.15% Mg

Magnesium concentrations in the clovers were roughly doubled from 0.1 per cent to 0.2 per cent by the application of 2 cwt of Epsom-salt per acre, but the grass magnesium levels changed far less. This increase in magnesium level in the clover was noted two months after application of the topdressing. Analyses of the herbage from the plots without magnesium consistently showed very low levels in all cuts.

Critical levels of about 0.12 per cent of magnesium in white clover and 0.14 per cent in red clover are indicated. The evidence for the grasses is not so clear, but it would appear that the critical level is about 0.10 per cent magnesium. Below these critical levels marked deficiency symptoms show up on the clover leaves. These symptoms are a marked reddening of the foliage at most times of the year. In white clover there is slight intervenal chlorosis and general yellowing usually accompanied by distinct reddening of parts of the leaflets; in red clover general chlorosis, frequently accompanied by intervenal necrosis, but the leaf margin is less affected.

CONCLUSION

The evidence available shows that a magnesium deficiency in pastures can be readily observed in the field.

Visual observations can be backed up by plant and soil analyses.

In the area investigated we would anticipate a response to applied magnesium where plant analyses showed levels of magnesium below 0.12 per cent for white clover, 0.14 per cent for red clover, and 0. 10 per cent for grasses. A soil level below 0.15 m.e. per cent would be suspect.

MAGNESIUM DEFICIENCY IN PASTURE YIELD DATA

(D.M. lb per acre)

Treatments	10.60	12.60	2.61	6.61
No lime	1060a	1930a	2630a	1020a
1 ton lime	1300a	2170a	2840a	1310a
2 cwt K	1250a	2060a	2700a	1150a
4 cwt K	1110a	2090a	2760a	1180a
No Mg	850bB	1730bB	2200bB	810bB
2 cwt Mg sulphate	1360aA	2190aA	3010aA	13 10aA
4 cwt Mg sulphate	1330aA	2300aA	2990aA	1380aA

Treatments	10.61	11.61	1.62	2.62	6.62
No lime	160a	600a	2450a	1060a	1360
1 ton lime	190a	820a	2510a	1260a	1020
2 cwt K	130bA	620bB	2270bA	1050bB	1180
4 cwt K	220aA	800aA	2680aA	1270aA	1210
No Mg	60bB	440bB	1790bB	800bB	990
2 cwt Mg sulphate	230aA	860aA	2880aA	1400aA	1360
4 cwt Mg sulphate	240aA	830aA	2760aA	1280aA	1200

RAINFALL FOR KAINGAROA FOREST NURSERY
Rates of Magnesium Trial
(Elevation: 1,800 ft A.S.L.)

	Rain in.	Wet days	Frosts
1959			
January	4.44	7	
February	4.71	11	
March	5.79	9	1
April	7.68	10	7
May	4.64	15	13
June	1.64	8	18
July	3.72	9	18
August	2.01	15	16
September	3.99	11	14
October	6.61	17	6
November	3.14	9	2
December	2.05	9	
Total: 50.54 in. rain in 130 days. 95 frosts.			
1960			
January	3.44	7	
February	12.70	16	
March	4.91	15	3
April	0.68	6	10
May	5.84	14	9
June	5.91	15	13
July	6.55	13	18
August	3.50	12	18
September	11.53	15	7
October	2.71	13	15
November	3.02	13	
December	2.04	9	
Total: 62.83 in. rain in 148 days. 83 frosts.			
1961			
January	5.33	14	
February	2.01	7	
March	3.54	7	3
April	4.59	9	6
May	2.61	10	9
June	5.63	21	14
July	5.64	19	16
August	3.57	7	18
September	6.10	14	13
October	4.18	7	4
November	1.63	3	3
December	5.19	12	1
Total: 50.02 in. rain in 130 days. 87 frosts.			
1962			
January	7.88	16	
February	2.02	10	
March	12.89	14	1
April	8.16	11	4
May	15.28	16	6
June	5.43	16	9
July	4.30	17	13
August	5.42	18	10
September	5.62	15	9
Total to end September: 67.00 in. rain in 133 days. 52 frosts.			

DISCUSSION

Q. (Prof. Welte): This is apparently the type of soil which requires both potassium and magnesium. Did you include plots that were top-dressed with magnesium sulphate only or plots top-dressed with only potassium chloride so as to get a comparison?

A. No.

Q. Would you comment on the use of serpentine superphosphate as a means of combating magnesium deficiency on pumice country?

A. I could comment at length on the use of serpentine superphosphate but not for the purpose of correcting magnesium deficiency in the pumice country, because as yet we have not found magnesium deficiency on farms. A considerable number of soil samples have been taken and roughly about 5 per cent of these show low levels of magnesium in specified areas of the pumice country, but as yet there is no clear indication of magnesium deficiency on farms. I will now put my head in the lion's mouth and say that serpentine super would appear to be, in the future, a fairly practical method of applying magnesium to pastures which may be found to be magnesium deficient.

Q. Have there been other trials showing this deficiency?

A. This trial and the one at Whaka was the first replicated trial showing a magnesium response, several earlier trials claiming to show a magnesium response were found to be due either to molybdenum or calcium carbonate content.

Q. It is noted that you have used magnesium sulphate in this trial. Did you have a plot that had only sulphur in it, and is there a response to sulphur in this area of the pumice country?

A. There is no plot containing only sulphur. The fact that so much super phosphate was applied during the lifetime of the trial would nullify any possibility of a sulphur deficiency while this trial was being conducted. In other parts of the pumice country there have been indications of a sulphur response.

Q. This discoloration in clover leaves has previously been associated with a nitrogen deficiency; would you care to comment on this?

A. Yes; the plant is deficient in nitrogen through the lack of magnesium restricting photosynthesis. I am not surprised that you should associate it in this way because until we had these clear-cut trials you would not possibly have seen it before, except perhaps in a periodical. That is why I feel it is so important to observe these symptoms in situ. Once you have seen the symptom, it would be firmly fixed in your mind's eye and I am confident that you would pick it anywhere. Of course discoloration of clover leaves can be due to many factors but once you have seen such an effect from a magnesium deficiency trial I doubt whether you would confuse it with anything else.

Q. When you get an effect like this are all plants affected, or is it only individual plants that are affected in this way?

A. In the spring you start off with only a few plants showing signs of magnesium deficiency but as time goes on, more and more of the clover plants show it; they are lacking in vigour and in fact disappear. On a large area eventually all the clover foliage would show these symptoms and in due course disappear.

Q. What practical implications arise from this work, seeing that you have used 2 cwt. of Epsom salts and have also shown that the residual effect was of short duration. What can be done in practice to overcome a situation of this type?

A. I would like to treat this question on a broad basis. The first practical results from such a trial are self-educational; we are now on first base and have a starting platform as advisory officers to work on and can recognise magnesium deficiency whenever it occurs.

We have a base on this particular soil on which we get a response, we have the plant level and it is here in New Zealand, not overseas.

To project into the future it is fairly clear that there will be areas of magnesium deficiency in pasture and by that time there may be other more concentrated and less costly forms of magnesium available, possibly incorporated with your superphosphate, similar to the way you combine molybdenum with superphosphate.