TRACE ELEMENT TRIALS AT INVERMAY RESEARCH STATION

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During the past six years trials have been carried out at Invermay Research Station with the trace elements molybdenum, vanadium, boron, copper and cobalt.

Though my paper is concerned mainly with these elements, and molybdenum in particular, I have also included results of sulphur and magnesium trials.

Most of the trace element trials have been laid down on the second class hill country at the Station. The Invermay hill country is typical of large areas of foothill country in the South Island, being deficient in phosphate, lime and some trace elements. In its natural state it is characterised by a low-producing browntop-dominant sward usually deficient in legumes.

The soil is silt loam overlying clay and readily responds to lime, phosphates and molybdenum. The available molybdenum (oxalate extract) ranges from 0.03 to 0.09 p.p.m.

DETAILS OF MOLYBDENUM. TRIALS

The first molybdenum investigations were commenced in December 1950 when a trial was laid down with lime and molybdenum treatments. These included lime at four rates, namely: No lime, ¾ ton, 1½ tons and 3 tons per acre, with and without molybdenum at 2½ oz. per acre.

Molybdenum responses were noted in this trial soon after application, and at the first cut one month after the trial was laid down the molybdenum treatments yielded nearly one third more than the no molybdenum plots. The response appeared to be largely a clover one, the clover being denser, darker in colour and more vigorous in growth in the molybdenum plots.

Even in the no lime treatments molybdenum gave good results, though the highest yields were from those receiving some lime in addition.

Three tons of lime without molybdenum proved comparable to the molybdenum treatments, but in the

presence of molybdenum three tons were little better than no lime.

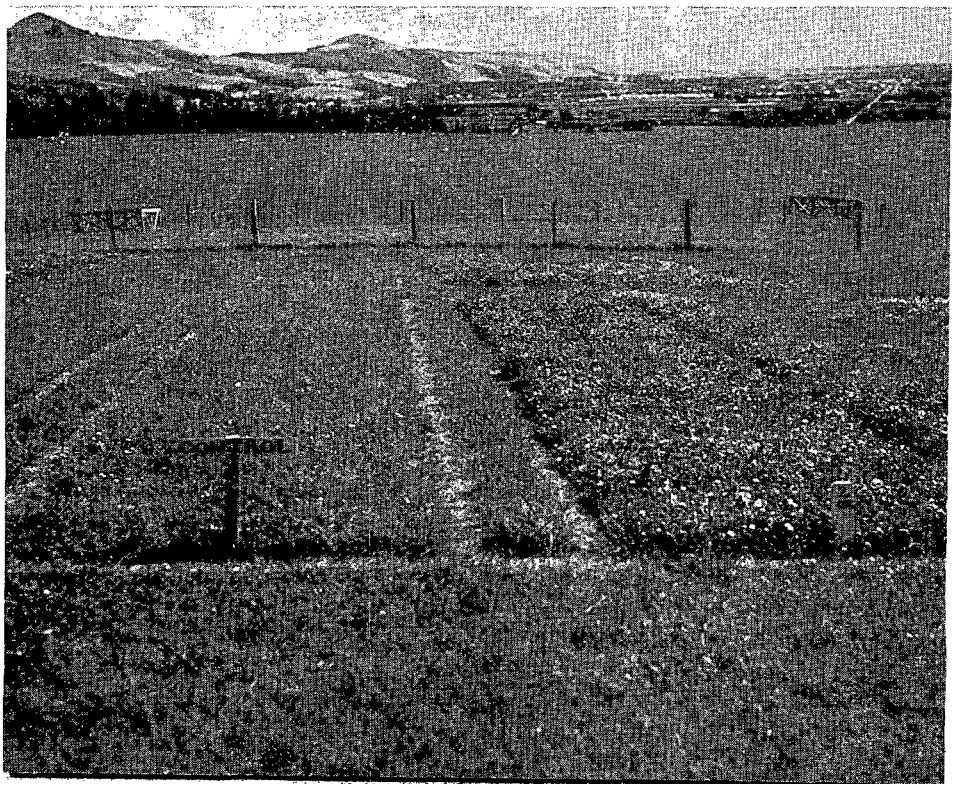
Soil samples from this trial have been taken regularly, and from the analyses it is apparent that most of the molybdenum is retained in the top inch of the soil for the first year or so. Some downward movement had taken place after three years,

In September 1953 the treatments were repeated on half the plots to investigate the duration of response to the original treatments, and to find out when repeat applications would be necessary. Though no response was noted during the third season distinct though small responses to the repeat molybdenum applications were noted in the fourth season. This suggests that one application of 2½ oz. per acre is sufficient for about four years on this soil type.

In September 1952 further mowing trials were laid down on a poor browntopdominant sward containing few clovers.

Molybdenum responses were so spectacular in these trials that the results will be treated in some detail.

Molybdenum triai at Invermay. Control plot treated with 10 cwt. lime and 6 cwt. superphosphate per acre. Plot on right treated the same as control, plus 2 oz. sodium molybdate per acre.



RATES OF MOLYBDENUM

This trial was laid down with eight rates of sodium molybdate namely: l-32 oz., 1-16 oz., $\frac{1}{8}$ oz., $\frac{1}{4}$ oz., $\frac{1}{2}$ oz., 1 oz., and 2 oz. A basal dressing of $\frac{1}{2}$ ton lime, 3 cwt. super and 1 cwt. muriate of potash was applied at laying down and all plots were oversown with white and red clovers.

Soon after application good molybdenum responses were noted with the higher rates and, by the end of the season, clover density, vigour and colour had improved noticeably in the molybdenum treated plots.

During the 1954-55 season very large increases were recorded in the molybdenum plots, dry matter ranging from less than 4,000 lb. in the control (no molybdenum) plots to over 11,000 lb. in the 2 oz. plots.

Yield figures for the 1952-53, 1953-54 and 1954-55 seasons are shown in the following table:

TABLE 1

Dry Matter Production: Seasons 1952-53, 53-54, 54-55

	Control	1-32oz.	1-16oz.	Qoz.	¼oz	½oz.	loz.	202.
1952-53	4,800	5,610	5,610	5,650	5,950	6,270	6,280	6,090
1953-54	2,930	4,280	4,200	4,880	5,920	6,670	6,980	6,670
1954-55	3,930	6,520	5,760	7,170	9,130	10,370	11,310	11,060
	11,660	16,410	15,570	17,700	21,000	23,310	24,570	23,820

It can be seen that even l-32 oz. has given a marked increase, though not comparable with that from the higher rate. Two oz. proved no more effective than 1 oz. and 1 oz. only slightly better than ½ oz.

TIMES OF APPLICATION OF MOLYBDENUM TRIAL

In this trial plots were laid down in September, November, January and March to investigate times of application of molybdenum. Results indicated that molybdenum applications can be made at any time of the year.

LIME,, PHOSPHATE AND MOLYBDENUM TRIAL

This trial includes block treatments of 2 tons lime, 5 cwt. lime, 2 tons lime + molybdenum and 5 cwt. lime + molybdenum (1¼ oz.). Within each block are sub-plots of super, Gafsa, Nauru and Christmas Island rock phosphates together with a control plot.

In this trial also molybdenum responses were outstanding, especially in the presence of super. Results were very poor in those super plots which received no molybdenum. The deficiency of molybdenum is evidently a limiting factor to growth in these plots.

To date yields from the rock phosphate treatments have been low, especially in the presence of lime. The yields from these plots have been similar to those from the control plots.

Lime has increased yields only slightly in. the molybdenum treated plots. Though yields from the super plots are slightly higher in the presence of lime, those from the rock phosphates are less.

All plots in this trial were oversown with white and Montgomery red clovers. The molybdenum treated plots now show a clover content of about 40-50% compared with less than 10% in the untreated plots.

This trial emphasises the importance of using phosphates and molybdenum together.

EFFECT OF MOLYBDENUM ON CLOVER SPECIES

Molybdenum treatments were applied to N.Z. white clover, subterranean clover, red clover, and *Lotus* major in February 1952. Though no marked molybdenum responses were noted in the first season, good responses were obtained in the second season, but only on the white clover, subterranean clover and *Lotus major* plots. No response was noted on red clover till the third season, when good results were obtained.

Molybdenum treatment applied to a pure ryegrass sward has no result.

EFFECT ON GRAZING ANIMALS

In a paddock scale trial, rates of sodium molybdate up to ½ lb. per acre were applied for two consecutive years without any affect on lamb thrift. Though. molybdenum levels in the herbage reached danger levels (10 p.p.m.) one month after application the herbage dropped rapidly to a lower figure (4 p.p.m.) after two months, and 2.5 p.p.m. after 5 months. Levels were similar following the second application in August 1954.

EFFECT ON CROPS

Good molybdenum responses have been obtained on both oats and rape on the Station . In one yield trial on oats 2½ oz. sodium molybdate per acre increased the yield by nearly 50%.

TABLE 2

Dry Matter Yields for 1953-54 and 1954-55 Seasons

Treatment	Gafsa 3 cwt.		Nauru 3 cwt.		Christmas Is.		Super 3 cwt.		Control	
	53-54	54-55	53-54	54-55	53-54	54-55	53-54	54-55	53-54	54-55
2 ton lime	2,500	4,680	2,330	4,750	2,330	4,490	3,070	6,830	2,760	4,600
5cwt. lime	2,200	2,980	2,130	2,570	2,030	2,580	2,070	4,060	1,900	2,680
5cwt. lime + Mo.	5,150	8,330	4,520	7,520	4,710	7,450	6,270	9,350	4,080	5,320
2 ton lime + Mo.	2,700	7,570	4,610	7,250	4,750	7,090	6,890	9,940	4,910	7,110

Note the high yields in the Super + Mo. plots.

OTHER TRACE ELEMENT TRIALS

BORON

BORON. This element is used on the Station for the prevention of brown heart in swedes. Two trials on pasture and one on lucerne have given no responses to date. Boron actually appeared to depress growth in one trial, but this may have been due to its burning effect on the herbage. A high rate, 40 lb. per acre of borax, was applied in this instance.

COPPER. Two trials on pasture showed no pasture response and had no effect on stock thrift. Copper levels on the Station appear satisfactory (about 7 p.p.m.) in the herbage.

COBALT. Although there are no indications of cobalt deficiency in lambs raised on the Station cobalt was tried as a drench giving.7 milligrams per week of cobalt sulphate for a four-weekly period. Fifty-four drenched lambs showed little improvement in rate of gain compared with a similar number of controls. (Treated 7½ lb., untreated 7 lb. live weight gain.)

VANADIUM. A slight response was noted in one trial, but results were not comparable with those from molybdenum.

SULPHUR. Since sulphur is applied in ordinary super as calcium sulphate its importance is often overlooked. In recent years excellent sulphur responses have been obtained in North Otago, Canterbury and parts of the North Island.

Sulphur treatments have been included in three trials at Invermay, but little, if any, effect has been noted. A trial laid down in November 1951 compared calcium sulphate and double-super treatments, alone and in combination with superphosphate. No sulphur response has been recorded in this trial to date, though good phosphate responses have been obtained in both the super and the double-super plots.

MAGNESIUM. This element has been included in one trial, but no response has been noted to date. In some trials where serpentine super has given good results this has been attributed to its magnesium content. However, at Invermay, serpentine super has proved less efficient than straight super.

CONCLUSION

The foothill country at Invermay Research Station has proved very responsive to molybdenum, even very low rates giving large increases in production.

On many similarly responsive soil types, particularly on the foothills of Otago and Southland, the use

of molybdenum in conjunction with phosphate has already resulted in a large improvement of much hill country with consequent increases in production.

With the exception of boron, which is necessary for the prevention of brown heart in swedes, few responses have been recorded to date at Invermay with other trace elements.

However, since trace element deficiencies may be induced by management practices such as continued heavy liming, factorial trials are in progress to investigate the interactions and responses from a number of major and minor elements used alone and in combination.

DISCUSSION ON TWO PREVIOUS PAPERS

Dr. Melville: Mr During's paper has been the best appraisal I have heard so far on the relative importance of trace element and major element deficiencies; this is important and timely.

Q. Speakers have restricted remarks to pasture responses. Could some information be given on effects of trace elements on animal health ?

A. (During): Copper: In many cases but not in all cases pasture responses are found on soils on which topdressing with copper is known to be essential to maintain animal health. Molybdenum: Where responses in pasture growth occur it is thought that molybdenum applications are safe from the animal health point of view provided the minimum rate of molybdenum is applied necessary to stimulate plant growth. Unfortunately this minimum rate is not usually known. When advising the use of molybdic super at usual rates we find it necessary therefore to advise-topdressing with copper on a limited number of soils, which are known to supply little copper to the plant.

Q. Cobalt was tried at Invermay on the growth rate of lambs with no effect. Have any investigations been made of the effect of cobalt on stock fertility?

A. (Dr. Filmer): Cobalt will markedly improve animal thrift at a deficiency level not drastic enough to affect the fertility of the animal.

Q. Is vanadium essential for plant growth?

A. (During): Vanadium is not proved to be essential for the growth of higher plants. Responses recorded in Northland may be due to several factors. Possibly vanadium displaces some molybdenum in the soil.

Q. What is the best form and method to apply copper.

A. (During): Use copperised superphosphate. It contains 2½ % bluestone.

Q. (Dr. Sears): Have you any information on the response to molybdenum of grasses compared with clovers, at Invermay, where grasses were adequately supplied with nitrogen?

A. (Cullen): On a pure grass sward no molybdenum response occurred. It is possible however that the nitrogen supply was not quite high enough.

Q. (E. D. Andrews): Boron applications have been stated to have given better fat lambs in Southland. Is it possible that this is due to a stimulus in white clover growth ?

A. (During): We have no evidence of clover responses to boron in Southland. One would expect marked boron deficiency in lucerne before clover would be affected. There is no evidence of boron deficiency in lucerne.

Q. (Dr. Mitchell): What 'work has been done in New Zealand with less soluble forms of molybdenum?

A. (During) : Very little work has been done. In two observational trials molybdenum trioxide and molybdenum frit respectively have been no better than sodium molybdate applied at the equivalent rate. We have started a mowing trial at Marton comparing three forms of molybdenum at different rates. Does anybody know the solubility of molybdenum in molybdic super?

Dr. Doak: Molybdenum in mdlybdic super is practically all water soluble.

Q. Are soil analyses useful in detecting mineral deficiencies.

A. (During): All chemical methods need testing against field trials and no satisfactory soil tests will be available for detecting trace elements until this has been done on a large scale. At present we are using soil and plant chemical tests for spotting soils on which field trials may promise success. Many of these tests are tedious. We would have to prove a very high degree of accuracy before their use for advisory work would become worthwhile.