
GROWTH INHIBITION IN SOME MARLBOROUGH SOILS

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The problem I am going to discuss, which is seen in its most severe form on the Wither Hills near Blenheim, is predominantly one of securing clover establishment from oversowing, although unthrifty growth following establishment is apparently another facet of the same problem. The trouble does not appear to exist—certainly not in a severe form—when cultivation accompanied by liming and appropriate fertilising is adopted.

Typical behaviour of seedlings on problem country is for the cotyledons to turn yellow at an early stage. The seedling, when it reaches the true-leaf stage, assumes an unthrifty appearance. It often turns reddish in colour and usually dies. Some plants will continue to grow, but show marked lack of vigour. Odd plants grow normally and tend to spread outward year by year, forming a healthy colony. This results in a patchy growth of clover. The patches form all sorts of irregular patterns that are not in any way related to uneven sowing of seed.

The general result of the problem is that it is quite uneconomic to **OVERSOW** clover on country where the trouble is marked.

My contention is that the problem is the result of growth-inhibitory factors in the soil. Just what the inhibitors are and how they affect the establishing or growing plant are not apparent, but it is suggested that soil fungi could be responsible. This is merely a deduction arrived at from circumstantial evidence. Firstly, the efficiency of fungicides, such as formalin, points this way and again the pattern of clover establishment on problem country could fit in with fungal infestation of the soil.

It would appear that efficient functioning of nodule bacteria is affected. Many unthrifty seedlings are found to be nodulated, but almost invariably the nodules are small and rather ineffective looking.

Extent of the Problem

I believe the problem is very widespread. It occurs in Marlborough on several soil types and under widely varying climatic conditions; and there appears no reason to suspect that it is confined to this province.

The problem is at its worst on the nearby Wither Hills on the Wither silt loam and the Waihopai stony silt loam. It occurs also on the Kenepuru, Flaxbourne, Woodbank, and other soil types, varying in severity from place to place.

Quite apart from cases of complete failure with clover establishment, there would appear to be a vast area of country where clover establishes and grows indifferently, resulting, of course, in waste of fertiliser and loss of production.

In Marlborough the problem is known to exist under annual rainfall varying from 24 to over 60 in. There is little doubt that in this province alone many thousands of acres are affected.

An interesting feature is that the problem is worst on clear, weed-free country and it appears that danthonia is always at least a component of the sward on problem areas.

Earlier Work on Problem

It was thought initially that the problem was due to some mineral deficiency in the soil, and earlier work was confined to the use of lime and major-element fertilisers. However, this work yielded little result apart from some benefit from lime. Later, molybdenum and other trace elements were tried, but only molybdenum showed any promise. This element and lime were of assistance, but certainly did not give the complete answer.

Heavy applications of lime (up to 3 tons per acre) and serpentine superphosphate (up to 1 ton per acre) failed to give satisfactory results.

In addition to this work, seed treatments were used in an endeavour to overcome or reduce the problem. Pelleting with various substances such as lime, basic slag, magnesium carbonate, carbon, and soil failed to have any useful effect.

Wither Hills soil was sent to Dr I. Blair several years ago for incorporation in nodulation trials. Lucerne failed to nodulate satisfactorily in this soil.

Results from Soil Sterilisation

In the late winter of 1959 a soil-sterilisation treatment was incorporated in a trial, using various types of seed pellets and fertilisers. A strip across the other treatments was sterilised with formalin several weeks before over-sowing. This trial yielded the first ray of hope, for only on the formalin strip did any clover establish. Most of the cross-treatments produced clover on this strip.

This was really the commencement of concentrated work with soil sterilants. The following year a trial incorporating the use of formalin, Jeyes fluid, cosan, thiram, vapam, and burnt lime was laid down. The two best treatments here were formalin and vapam, with the former outstandingly the better.

The formalin treatment used at this stage was 1 gallon of 20 per cent solution per square yard, the treated area being covered with plastic sheeting for two to three days with a lapse of three weeks before sowing of seed. This treatment gives a complete turf kill and is invariably followed by an excellent establishment of both grass and clover.

In later treatments **much** smaller quantities of formalin have been used successfully without the necessity of covering the area after application. For example, a very successful treatment has been 50 to 75 gallons of neat formalin per acre sprayed on and followed by a light watering to take the formalin down into the surface soil (1 3 pints per square yard has proved to be a suitable amount of water). This treatment gives a turf burn, but usually does not kill all the growth. Seeding can take place about a week after treatment.

Extent of Response

The extent of the response after formalin treatment is really fantastic and quite beyond what could reasonably be expected. On some of the formalin-treated plots on the inhospitable Wither Hills soil white clover has grown with such vigour that the leaf size has exceeded that of the most vigorous clover I have seen on the best flat land and runners have reached a length of 2 ft 6 in. one year after oversowing.

While the effect on clover growth is the outstanding feature after treatment, benefits are not confined to this type of plant. Weeds of various types, such as thistles and flat weeds, become exceptionally vigorous. In fact, they suddenly appear "out of the blue" where their presence was not suspected. Oversown grasses, too, such as ryegrass and cocksfoot, establish well and exhibit unnatural vigour.

Other Materials

Other turf-killing materials such as 2,2-DPA and TCA have a similar effect to formalin, but are not as quick and effective.

In one replicated trial on the Wither Reserve the 2,2-DPA plot was a long way behind the formalin nine months after sowing, but had almost equalised three months later. At this stage white clover was growing very vigorously on both plots. In fact, its vigour was equal to that of clover on the best flat land.



Fig. 1: Vigorous growth of white clover following formalin treatment of soil (right) just over a year after oversowing. Same manurial and oversowing treatment on left. Area burned annually for many years before treatment.

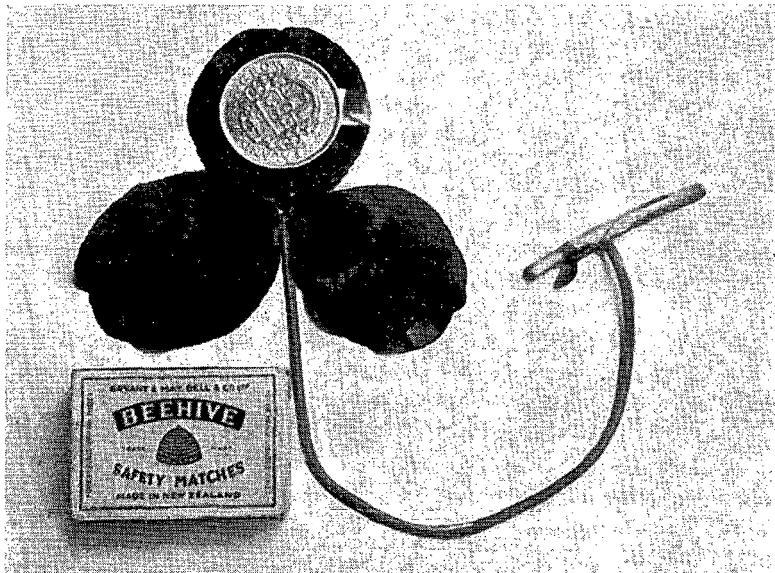


Fig. 2: A half-crown piece fails to cover a white clover leaf grown after formalin treatment on country that will not normally grow clover.

It appears to me that these materials, which are well known in chemical ploughing, have some effect in the soil that has not been **fully** appreciated and that action, I believe, is one of controlling growth inhibitors in the soil. I have no doubt that the elimination of plant competition and the eventual provision of a certain **amount** of organic matter and nitrogen are, in many instances, merely useful side effects. This contention is supported by the fact that the **formalin** treatment on a bare slip face **encouraged** the establishment of clover and grass.

Let us look at the place where chemical ploughing had its birth, on the Wrekin property near Blenheim. I cannot believe that the phenomenal growth of clovers, weeds, and grasses after the spraying of the nassella tussock was due merely to elimination of competition and release of nitrogen. The plants grew to several times their normal sizes on this inherently poor country.

Formalin is **the** most efficient material I have used on these problem soils, but **2,2-DPA** and TCA are also good. Diquat, paraquat, etc., may **well** prove very effective, but sufficient work has not yet been done with them under these conditions.

Practical Significance

Although **formalin** overcomes the problem of clover-establishment on these difficult soils, it does not impress as a practical solution of the problem, as there would be difficulties in its application. However, I believe it has served a very useful purpose in this district in indicating that growth inhibitors are a problem in some soils.

Only detailed work by micro-biologists will reveal whether this is correct and just what the causative factors are, but in the meantime the most important matter would appear to be the securing of some practical treatment to overcome the problem. Work in this direction is now well under way and indications are that **2,2-DPA** could provide a reasonable treatment at 5 lb per acre. However, work with other, more economic treatments is showing promise. Bluestone at 5 to 10 lb per acre is giving good results and santobrite at similar rates is also showing promise, **but** further work is required to confirm these results.

If these materials provide a satisfactory solution under all conditions, they could be an advantage in avoiding a turf kill, as well as being more economical than **2,2-DPA** or formalin. These materials, too, could be used on pasture where some native clovers are present with the idea of encouraging establishment of the better classes of clovers without affecting those **present**.

Of course, there are advantages at times in passing directly from poor native pasture (such as danthonia) to a first-class pasture incorporating ryegrass, cocksfoot, and clover. In such instances, turf killing with 2,2-DPA would be indicated, provided the better class grasses could be maintained permanently.

From general observations since commencing this work, I am convinced that there is considerable subnormal growth of plants over wide areas resulting from inhibitory, rather than deficiency, soil factors. Frequently, for example, the cotyledons of clover seedlings are seen to be yellow at an early stage while in other cases they maintain the normal, healthy green appearance for quite an extended period. This may be due to some other known factor and if any of the conference members have investigated this matter, I would be interested to have any available information.

I suspect that soil erosion on certain soil types (such as the Wither silt loam) is due to a lack of good soil structure caused basically by growth inhibitors in the soil. I am quite convinced that if clover could be established successfully on the Wither Hills by the treatments described, or by some other means, soil erosion would quickly disappear.

It has often been stated that frequent burning of dry danthonia country "destroys" the soil. Does it really do so, or does it perhaps encourage the multiplication of growth inhibitors in the soil? On poor danthonia country which has been burnt **off annually** for many years in one of the driest parts of Marlborough, **oversown** white clover on a formalin-treated plot has exhibited vigour and health equal to that of clover on our most fertile land.

Instances, too, have been reported throughout the country where unexpected growth responses have been obtained to copper. Are these all due to copper deficiency in the soil or could they be due to fungicidal action of the copper?

Although good results have been obtained by treating the problem soils in Marlborough with **formalin** and other materials, the problem remains obscure and intriguing. Further replicated trials incorporating the most promising treatments evolved to date are under way and additional information may be available from these in the near future. Dr Parle of Rukuhia Soil Research Station, Dr Thornton of the Soil Bureau, Wellington, and the Plant Diseases Division, Auckland, have recently started work on the problem and it is hoped that further useful information will be forthcoming from these quarters.

In any case I am convinced that the problem is most important and the investigations under way could provide a new and fruitful approach to the improvement of soil fertility over wide areas.

Acknowledgements

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DISCUSSION

Q. (Mr Woodcock): Have you used inoculated white clover seed in the trial results you have shown?

Because formalin is an expensive material have you tried a really good burnt lime?

A. Yes, I used inoculated clover on most of the trials. You did, however, see a trial yesterday heavily treated with formalin where two plots were sown with inoculated clover seed, and two with non-inoculated clover. As you saw for yourselves, the clover established well in both plots. It may have been slightly superior in the inoculated plot.

With regard to the use of burnt lime, I am not prepared to say how good the lime was, but it was from a sealed container and in quite hard form when we used it.

Q. (E. Madden): Did you use copper sulphate in the form of crystals or was it used in solution?

A. It was used both ways and proved effective in both cases.

Q. What was the rate of application?

A. 5 and 10 lb to the acre.

Q. Was this considered sufficient to sterilise anything?

A. Apparently it had some mild effect on sterilisation of the Marlborough soils.

Comment (I. Parle): I don't believe that copper sulphate has a very marked ability to sterilise soil. In some work which I did a few years ago on peat soils I found remarkably little evidence that even heavy rates, e.g., 80 lb CuSO_4 per acre had much effect on soil micro-organisms.

Q. (G. Robinson): Is the recovery of sub clover good in the year following establishment?

A. Yes, the clovers carry on in the second year just as well.

Q. Have you considered the use of fire, not so much in the Wither Hill areas, but in the high rainfall areas?

A. It is common practice to burn fern in the high rainfall areas and I imagine that burning has some effect. We had poor establishment on the Havelock block in clear country, but on adjoining country where there was fern there was a good establishment.

Q. (Prof. Langer): Is this problem inherent in the soil, or is it associated with vegetation? Would it be worthwhile to clear an area manually and attempt to establish the clovers after it has been so cleared?

A. My guess is that it is in the soil. Where you spray formalin on to the vegetation without any watering in, the results are not as good as where you apply a small amount of water ($1\frac{1}{2}$ pints to the square yard) to secure some soil penetration. It does appear that the effect is in the surface soil.