THE POSSIBILITIES OF CHEMICAL PLOUGHING ON HILL COUNTRY UNSUITABLE FOR CULTIVATION

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SUMMARY

THE classes of hill country unsuitable for cultivation are outlined. Reference is made to the trial work done in the Dannevirke district (Southern Hawke's Bay and Northern Wairarapa) since 1956 and detailed accounts are given of four chemical ploughing trials established by aerial means. The lessons learned from these trials and problems requiring further investigations are then dealt with. Finally the future prospects for chemical ploughing are discussed.

INTRODUCTION

Chemical ploughing means the killing of a sward with chemicals by spraying before oversowing with a seed mixture. The process is closely related to renovation, which is the selective killing of unwanted species in a sward and their replacement by oversowing with desirable species.

The classes of hill country which come within the scope of this paper include areas too steep to cultivate, too broken to cultivate satisfactorily; where there are physical obstacles such as rock or limestone; where cultivation may initiate erosion in areas of particularly high rainfall, or where serious windblowing is likely; land which is really too steep to be safely cultivated, and country which is cultivable but inaccessible to implements.

The information in this paper originates from experimental work done in the Dannevirke district since 1956 and also from two outside aerial trials, one at Tiritea in the Manawatu and the other at Waerenga-o-kuri, Gisborne. These two trials were laid down after the success of the Balfour Stud aerial trial at Pahiatua established two years previously. In all 29 trials have been carried out since 1956.

The preliminary work done between 1956 and 1958 consisted of small-scale hand-sprayed trials. The results were sufficiently encouraging to warrant an aerial trial being established in the autumn of 1958.

RESULTS OF AERIAL TRIALS

No. 1: Balfour Stud, Pahiatua

Description of site: Area 6½ acres (flat basis); soil type 77H, Matamau silt loam; elevation 400 to 500 ft; topography, too steep to cultivate; aspect, mainly north-east; sward, browntop (*Agrostis tenuis*) dominant, with danthonia (*Danthonia pilosa*), sweet vernal (*Anthoxanthum odoratum*), flatweeds (*Hypochaeris radicata* and *plantago lanceolata*), suckling clover (*Trifolium dubium*), and a little ryegrass (*Lolium perenne*), and volunteer white clover (*Trifolium repens*) in the damper depressions; previous topdressing, one application of 2 cwt of superphosphate per acre; previous carrying capacity, 1½ to 2 ewes per acre done fairly well and producing store lambs.

Climatic conditions: Average annual rainfall 52 in.; mean temperature range 54 degrees to 55 degrees F; rainfall, April 4 in., May, 5 in.

Spraying, sowing, and topdressing: The area was sprayed on 20 March 1958 with a Moth aircraft (triple coverage), applying 3.7 lb a.i. per acre of dalapon plus 0.5 lb a.i. per acre of amitrole in 20 gallons of water per acre. A 52 lb pasture mixture and 3 cwt of molybdc superphosphate per acre was sown by air on 10 April, 21 days after spraying. Between spraying and sowing 2.5 in. of rain fell. On 20 May 12 cwt of 90 per cent lime per

acre was applied. Over the three-year period the trial has received a total of 9 cwt of superphosphate.

From the six soil tests taken over the three years at two levels the available phosphate and potash were twice as high at the 0 to 1½ in. level as they were at the 1½ to 3 in. level. Average figures were:

Phosphate	at 0 to 1½ in. = 4.3
	at 1½ to 3 in. = 1.8
Potash	at 0 to 1½ in. = 9.5
	at 1½ to 3 in. = 4.8

Cost of establishment: £16 18s. per acre, including chemicals £7 2s., fertilisers and lime £3 19s., and seed £5 17s. All these amounts include aerial application costs.

Results: The results from this trial were quite spectacular and at its peak in October-November appeared as good as a first-class dairy pasture. The pasture, however, became strongly clover-dominant over the late summer and early autumn, resulting in the smothering out of a good deal of ryegrass. During the first season mainly cattle were used to control growth; however from the second season on the area has been set stocked with ewes, cattle being moved in and out as required to control growth.

1959-60 season: The area carried 34 ewes (5 per acre) which produced 43 Romney lambs. A total of 65 per cent of these lambs were picked fat on 22 February 1960 (about six months of age). The average liveweight of all the lambs was 73.4 lb, with an estimated average of 32.7 lb carcass weight.

1960-61 season: The area carried 39 Romney ewes (5.8 per acre) to the Southdown ram, yielding 42 lambs. Of these lambs 27 or 64 per cent were picked fat off the mothers on 17 January 1961 (four months of age). The average carcass weight of these was 33.2 lb. On 15 February 12 of the remaining lambs were sent to the works in error before fattening was completed. These averaged only just over 27 lb carcass weight. The 3 tail-end lambs that were kept on the area until 12 April averaged 31.5 lb carcass weight. The trial area up to the time the lambs were weaned in January 1961 was all one paddock. At weaning time one subdivision fence was erected to keep the lambs from the ewes.

1961-62 season: The area was reduced to 6½ acres, ¼ acre of valley flat being taken from the trial. Forty-five 4-tooth Romney ewes (6.9 per acre) were put on the area the same day as the last season's ewes were removed (17 January 1961).

No. 2: A. W. L. Lohrey, Tiritea, Manawatu

Description of site: Area 6½ acres; elevation 400 to 500 ft; topography, one-third rolling and the remainder very steep; aspect, north-west and south-west; sward browntop dominant with danthonia, dogstail (*Cynosurus cristatus*), and suckling clover, and a little fog (*Holcus lanatus*), ryegrass and white clover in the more fertile depressions; previous topdressing, 2 cwt of superphosphate in 1958 and 2 cwt of molybdic superphosphate in the autumn of 1960; previous carrying capacity about 2 ewes per acre.

Climatic conditions: Annual rainfall 45 to 50 in.; average rainfall for the critical months of April and May, 3.34 and 3.53 in. respectively; mean temperature range 54 degrees to 55 degrees F.

Spraying, sowing, and topdressing: The area was sprayed on 17 March 1960 with a Cessna aircraft (double coverage), applying 3.7 lb a.i. per acre of dalapon plus 0.5 lb a.i. per acre of amitrole in 20 gallons of water per acre. A 42 lb pasture mixture was sown by air on 30 March, 14 days after spraying. In early August ¼ ton of lime and 3 cwt of molybdic superphosphate per acre were applied.

Cost of establishment: £17 13s. per acre, including chemicals £6 12s., fertiliser and lime £4 16s., and seed £6 4s. 7d. All these amounts include aerial costs.

Results: The strike and establishment on the north-west face were poor on the drier portions, but quite fair on the damper parts. The results on the rolling area and south-west face are moderately good. The paddock has received a definite boost. It is being set stocked at the rate of six ewes per acre.

While the result is not as good as hoped for, there were two important reasons for this. The driest April (0.9 in. compared with the average of 3.34 in.) for many years was followed by a drier than average May (2.25 in. compared with the average of 3.53 in.). Also Porina damage was quite heavy and was no doubt responsible for the loss of seedlings and for retarding establishment. A good deal of the seed on the north-west face was probably eaten by birds, as the soil did not become wet until well on into the winter.

No. 3: Waerenga-o-kuri, Gisborne

Description of site: There were two areas: Paddock A of 9 acres was chemically ploughed and sown with a full pasture mixture and paddock B of 7.4 acres was oversown with white clover only; soil type, 21H, Gisborne sandy loam; elevation, 600 to 800 ft; topography, steep to very steep; aspect, north-westerly; sward browntop dominant with danthonia, ratstail (*Sporobolus capensis*), paspalum (*Paspalum dilatatum*), dogtail, goosegrass (*Bromus mollis*), white clover, and subterranean clover (*Trifolium subterraneum*); area previously topdressed with 2 cwt of superphosphate in 1955 and again in 1957.

Climatic conditions: Average annual rainfall, 50 in.; average rainfall for the critical months of April and May 4.3 and 6.6 in. respectively, mean temperature range, 56 degrees to 57 degrees F.

Spraying, sowing, and topdressing: The area was sprayed on 21 May 1960 with a Cessna aircraft (double coverage), applying 3.7 lb a.i. per acre of dalapon and 0.5 lb a.i. per acre of amitrole in 20 gallons of water per acre. A 43 lb pasture mixture was sown by air on 2 June, 12 days after spraying. Between spraying and sowing 1.68 in. of rain fell. Both paddocks were topdressed with superphosphate at 5 cwt per acre.

Cost of establishment: £15 5s., including chemicals £5 16s., fertiliser £4, seed £5 19s. 4d. All these amounts include aerial costs.

Results: There was a good initial strike of both grasses and clovers, but residual spray effects caused some of the early germinating ryegrass and most of the clover to die. This was probably due to the combined effects of a retarded rate of breakdown of the chemicals because of low bacterial activity at this time of the year and to the high soil moisture content which kept the chemicals near the surface. In spite of this the areas are now quite promising and the clovers are improving. No data are yet available about stocking.

No. 4: F. and B. L. McGregor, Horoeke, Southern Hawke's Bay

Description of site: Area 40 acres. Up to 50 per cent of this paddock is discable, the remainder being very steep and broken. Soil types, 28H Tinui silt loam, and 120, Mataikona silt loam. Both are of low natural fertility. Elevation 1,000 to 1,100 ft; aspect, mainly north-west and south-east with some faces exposed to the north-east and the south-west; sward, browntop, danthonia, dogtail, white, subterranean, and suckling clovers, flatweeds, and a trace only of ryegrass in the damper depressions; previous topdressing, topdressed annually with 1½ to 2 cwt of superphosphate per acre for nine years, with two oversowings of white and subterranean clovers at 1 lb per acre each, on two occasions; previous carrying capacity was 1½ ewes per acre, producing reasonable store lambs.

Climatic conditions: Average rainfall for critical months, April 4.76 in., May 5.18 in.; mean temperature range, 54 degrees to 55 degrees F.

Spraying, sowing, and topdressing: The area was sprayed on 7 March 1961 with a Cessna aircraft (double coverage), applying 3.7 lb a.i. per acre of dalapon and 0.5 lb a.i. per acre of amitrole in 20 gallons of water per acre. A 41 lb pasture mixture was sown on 6 April 30 days after spraying. Between spraying and sowing 2.32 in. of rain fell. On 28 March 2½ cwt of DDT superphosphate was applied.

Cost of establishment: £15 15s., including chemicals £5 16s., fertiliser £2 19s. 4d., seed £6 19s. 11d. All these amounts include aerial costs.

Results: There was a good initial turf kill; the overall strike was good and the trial is promising.

LESSONS LEARNED

The results from the four trials can be summarised as follows:

- Trial No. 1, very successful
- Trial No. 4, promising, but still in early stages
- Trial No. 3, fairly promising
- Trial No. 2, fair, but could improve considerably.

The results are encouraging and some important lessons have been learnt.

1. **Preparation of the land:** Paddocks should be kept under good control over the summer to prevent inferior species from setting seed and should be hard and evenly grazed in the late-summer early-autumn period and then allowed to freshen with the autumn rains.

2. **Time of spraying:** 3.7 lb a.i. per acre of dalapon and 0.5 lb a.i. per acre of amitrole in 20 gallons of water per acre are sufficient for a good sward kill **provided the area is double sprayed using a carefully set out marker system.** The paddock should be marked out in such a way that the plane flies over a line of markers every three or four runs. In the above trials the same markers were used for seed sowing. In all cases the spray and seed distribution was good.

Trials have proved conclusively that the autumn is a more suitable time for spraying and sowing than the spring. The best time for spraying where dalapon and amitrole are used is from the middle to the end of March. Spraying later than this, except in the warmer climates, is likely to leave too short a time for seed sowing after a period has been allowed for the residual effect of the chemicals to wear off. The use of non-residual sprays would, however, extend the spraying period considerably.

3. **The seedbed:** Swards have averaged ½ in. to 1 in. in height at spraying. This has proved quite satisfactory under the conditions experienced and with the chemicals used. In two of the trials pilot plots of clovers were sown to check for possible residual effects. The seed should be sown after all danger of residual effects is over. A delay of a fortnight or preferably three weeks after spraying and the fall of an inch of rain should make sowing quite safe. Given a reasonable amount of rain most of the seed usually strikes by the end of May, but the process continues until temperatures become too low. It has been noticed repeatedly that some seeds survive the winter and strike in the early spring when growth first starts. Where insect pests are present DDT should be applied. In many cases this would be necessary well in advance of the time of sowing.

4. **Management:** The initial establishment during the autumn and winter is considerably slower than for cultivated areas and no effective grazing can be expected until the spring. Favoured treatment should be given to the establishing pasture the first year, as it can be made or ruined at this stage. On-and-off grazing with large mobs is ideal and set stocking should preferably not begin until the autumn after establishment.

5. **Pasture mixtures:** These have purposely been high to allow for possible seed wastage due to any residual effects, insects, slugs, bird damage, or false seed strikes. In the case of Trial No. 4 there was a substantial volunteer strike of both subterranean and white clovers. This shows that where clovers have previously been successfully established the amount of clover seed sown can be greatly reduced.

PROBLEMS REQUIRING INVESTIGATION

1. Time of spraying in lower rainfall areas (under 40 in. per annum) especially in the colder districts.

It is probable that more often than not the weather becomes too cold for satisfactory germination by the time a plentiful supply of moisture is available for the seed to strike satisfactorily. Under these conditions it is suggested that late winter spraying and sowing (using a chemical with little or no residual effect) could well be the best approach. To prepare for this, autumn spelled pasture with a cover of up to 3 in. of leafage to provide sufficient material to form a good protective litter after spraying may be desirable. The importance of bird damage would have to be assessed.

2. The seedbed

The importance of insects, birds, slugs, and fungi in seed and seedling survival, especially for out-of-season sowing, requires further study.

FUTURE PROSPECTS

In assessing the part that chemicals may play in the future the following points should be considered:

1. Their use could result in a large increase in the productivity of our hill country.
2. There are good prospects for an improved range of chemicals at lower cost.
3. Techniques are likely to improve; for example, "spray-seeding" in which both spray and seed are flown on together would be practicable with sprays having no residual effects. An automatic pilot-guiding system and improvements in aircraft are other possibilities.
4. There could be a place for chemical cropping on at least a small scale on hill country. A period of fallowing after spraying is likely to be an important consideration, as demonstrated in a trial in this district last season.
5. With improved and cheaper results chemicals may compete with cultivation. This trend could be accentuated where chemicals are used because of the extremely low labour cost, the small amount of time involved, and the lower overhead cost of machinery per acre treated.
6. New plant material could be introduced into hill country swards. This would give a flexibility lacking at present. Who is prepared to say what the plant breeder will have to offer the hill country man in the future?
7. Renovation, as distinct from chemical ploughing, is likely to play an increasingly important part because the principle of removing inferior species from a pasture and replacing them with desirable ones is very sound. Apart from a greatly reduced risk of failure the sward would be out of production for a minimum of time, insect and slug damage would be reduced, while costs would be comparatively low.

The relative roles of chemical ploughing and renovation are likely to be influenced by the stage of development of the country and might be as follows:

1. **For unimproved country not previously oversown or topdressed.**
 - (a) Oversow with clover if experience shows that similar country gives good results. The area could be renovated some years later if desired.
 - (b) Chemical plough either where the clovers are difficult to establish or where new pasture on easier land of similar type gives substantial increases in carrying capacity. Trials in this district indicate that poor quality swards in the higher rainfall areas are likely to give good results.

2. For improved country that has been oversown and topdressed.

(a) Where the clover content is good and the grasses are poor renovate with a chemical such as paraquat accompanied by the oversowing of grasses.

(b) Where the clover and ryegrass contents are both good. Only experience will indicate whether selective grass killing chemicals have a place here. It is likely to be the last type of country tackled.

The above should not be regarded as a recommendation, but only as a likely future trend.

CONCLUSION

Chemical ploughing on hill country is still in the experimental stages and anyone wishing to try out the method should work under the guidance of someone who has had experience of the method. However, in time chemicals will be accepted as a powerful tool in shaping the future of grasslands. Chemicals will assist the animal in improving hill country more rapidly. Chemicals may improve hill country in two important ways: allow the introduction of desirable species in quantity and render fertilisers more effective through better compatibility between species.

Reference

Leonard, W. F. "Nassella Tussock Control", "N.Z. Journal of Agriculture", May 1961.

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DISCUSSION ON CHEMICAL PLOUGHING SESSION

Mr Bell—You normally spray dalapon in March, which means that you have to oversow in May. What happens if you use dalapon in January or February?

Mr Blackmore—We have applied dalapon then, but you run into the danger that you may be dealing with a fairly mature plant at that time, and that the plants have insufficient green leaf to get a kill. I think you want to spray as near as possible to the time of seeding.

Mr Currie—Paspalum is a problem because dalapon is not very effective on paspalum. Crickets normally come in and eat the germinating species or oversown species and I consider you get quicker results by sowing the grass/clover seed later and tramping it in by stock.

Mr Blackmore—If the paspalum is in the pasture in such a quantity as is going to affect the final issue, I think we've got to wait patiently until a chemical is produced that will handle paspalum, but I don't feel that in cases where the paspalum is not high that it would be an important issue. As for the crickets I think that probably the technique outlined by Mr Currie would be a good approach in that instance.

Dr Mason—If you apply the dalapon/amitrole eight weeks ahead, would not there be a terrific lot of weeds regrowth during that eight weeks prior to sowing the crop? This would also happen with paraquat.

Mr Blackmore—Yes, that could be so, depending on the country.

Mr Beggs—In the results obtained with chemical fallowing were they not simply due to residual effect of the dalapon and amitrole mix having a residual effect on the germinating seed and after a period of eight weeks under his rainfall conditions, the residual effects could have worn off.

Mr Blackmore—Yes, I feel the residual effect of the chemicals could come into it quite a bit, but I personally am fairly convinced that the fallow effect is important.

Mr Beggs—Did Mr Blackmore have a true control, that is a plot in which no spraying was carried out, but fertiliser and seed were sown?

Mr Blackmore—I feel that we have to do a lot more work in this direct comparison where stock are involved. In the Balfour trial it was initially browntop dominant sward of almost 99 per cent inferior grass. It was possible to take out the inferior grasses and replace with high fertility grasses. This cannot be done with oversowing.

Mr Thompson—Mr Porter mentions the difficulty of producing strawberries on low fertility ground and not being able to get the fertiliser down to the root zone. Does he regard that as being important and if he does, would he consider the use of a Ferti-plow to accomplish this?

Mr Porter—Firstly I think I would like to point out that the chemical method in strawberry growing would apply best to soil which has high fertility. On the soils which are not so fertile some work overseas has shown that fertiliser is definitely an advantage to strawberries.

Mr Crane—Mr Blackmore has not made any particular reference to soil type in his paper. This particular subject has been stressed at previous conferences and could Mr Blackmore elucidate.

Mr Blackmore—I feel that soil type is important mainly in so far as a soil type needs to be conditioned to produce a high producing pasture. On poor soils it is very difficult even with topdressing and oversowing to get the ryegrass to increase rapidly enough, even under good rainfall conditions.

With chemical ploughing provided the soil fertility requirements are met, establishment is quick, and stocking capacity increased from two ewes to say four or five within 12 months.

Comment:

Mr Burgess—There is not a need for a normal control in this chemical ploughing work, because you know what you set off with and you know within a very short time what you end up with, and those increases are quite staggering, as elucidated in Mr Blackmore's paper and I could also add to that in any of the small scale plot work we always do include an ordinary control. Of course that control is not subject to grazing management, which a lot of protagonists to the chemical method claim is an all important thing.

Mr Gregory—Would Mr Porter elaborate further on using selective materials in strawberry culture to minimise cultivation?

Mr Porter—To date the difficulty has been to get a residual herbicide to work on cultivated soil. Diquat plus simazine was equally effective on cultivated and non-cultivated soils. Chlorpropham was also effective.

Mr Gordon—Having followed this work for a few years it appears that the Department are seeking 100 per cent reliability of chemical ploughing methods before recommending its use.

Mr Matthews—On the molybdenum deficient soil type around Wellington in a high rainfall area it has been possible to repeat successes over four years. We have, as a Department, surveyed New Zealand fairly well. I am afraid most of our Farm Advisory Officers took the attitude, if this method is going to work, it will work on the toughest conditions that we can apply it to, and in a lot of cases trials have been put down under conditions where the fertility requirements of the soil are not known. The other big disadvantage in small scale work is that we have not been able to stock it correctly and without proper management results are not usually up to scratch.