ADVANCES IN PUMICE LAND DEVELOPMENT

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Summary

Field experiments, conducted mainly on the severely phosphorus deficient pumice soils of the Rangitaiki Plateau, have shown that pasture and lucerne will establish rapidly and grow vigorously, provided:

(1) The legume seed is inoculated and, preferably, coated.

(2) The seed is sown very early in spring, into a consolidated seedbed.

(3) A heavy rate of superphosphate is applied, 10 cwt/ac for pasure, and up to 20 cwt/ac for lucerne. Drilling of some phosphate fertilizer with the seed is desirable.

(4) Potassium and magnesium fertilizers are applied where necessary.

(5) The seedbed for lucerne is prepared with 1 ton/ac lime. The base fertilizer for this crop should include copper and boron, and the seed should be drilled with 3 cwt/ac lime.

INTRODUCTION

MOST of the development in Taupo County today is taking place on the extremely infertile soils of the Rangitaiki Plateau (above 2,000 ft elevation). Since land development is essentially a large-scale exercise in pasture establishment, the problems that occur are usually linked to one or more of the following factors: Seedbed preparation, time of sowing, soil fertility, and legume nodulation. In this paper it is proposed to comment on these factors and report the results of recent work,

SEEDBED PREPARATION

Cultivated pumice soils are difficult to consolidate if allowed to dry out. Yet, such simple procedures as rolling on the furrow to help conserve moisture, and tine harrowing to start consolidation from the bottom up are virtually unheard of. Instead, heavy discs, chain harrows, and the roller are commonly used. Often the result is a seedbed with a deceptively fine surface finish, but loose and spongy underneath. Seedling mortality can, therefore. be high.

TIME OF SOWING

Pastures are generally sown in October-November, or sometimes in 'Februai-y-March. These times woud appear to be a matter of convenience, determined by the time cultivation- work is completed (Brown, 1949). This is risky since soil moisture deficit 'increases towards the end of spring, and soil moisture levels at the end of summer are usually very low.

In an oversowing -experiment with white clover at Poronui Station (see Fig. 1, Toxopeus and Gordon, 1971), Rangitaiki, in 1967, late winter sowings (July-August) succeeded well, whereas from October onwards seedling survival dropped sharply (Table 1) . Thus autumn cultivation, winter fallow, and early

TABLE 1: WHITE CLOVER ESTABLISHMENT AT DIFFERENT TIMES OF SOWING

(Scale: 1 — trace, to 10 — abundant)

Time of Sowing	*Score, March 1969*
Mid July	6.9
End August	6.8
Mid-October	5.3
End November	3.8

spring sowing would seem the most suitable procedure, and this was recently adopted by the Department of Lands and Survey for the Whakatau development near Rangitaiki.

SOIL FERTILITY

Undeveloped pumice land usually has a soil test* of: pH 5.1 to 5.8; Ca, 1 to 2; K, 3 to 5; P, 0 to 2; S, 1 to 5; Mg, 5 to 10. This indicates a low status of nutrients essential for plant growth, notably phosphorus and sulphur, and to a lesser extent potassium.

PASTURE ESTABLISHMENT

Introduction

'The importance of topdressing for successful land development was fully recognized in the early thirties. 'Smallfield (1933) ad-

*Indices of-fertility status, as determined by the 'Department of Agriculture Soil-testing service; pH, Ca, K, P (Mountier *et al.*; *1966)*; S (Cooper, 1968) ; Mg (McNaught and Dorofaeff, 1965).

vised the use of 3 cwt/ac superphosphate at sowing, followed by 3 cwt/ac 4 months later. Potassium and lime gave little or no response, and nitrogenous fertilizers had only a short-lived effect on pasture growth.

Fertilizer placement with the seed was apparently not considered until the early fifties, when Sears et *al.* (1955) demonstrated that drilling the seed with 1 cwt/ac superphosphate was as good as 3 cwt/ac broadcast. In collaboration with the late M. W. Cross, this led to the construction of the first "roller-drill" with a fertilizer box attached.

However, the technique of placing fertilizer with the seed was evidently not adopted and the previous practice of broadcasting "3 plus 3" cwt/ac superphosphate continued.

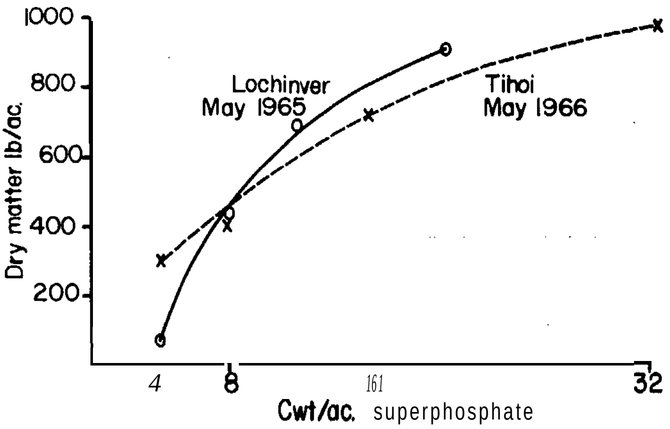

FIG. 1: *of* ***rates*** *of* ***superphosphate applied at sowing on the growth*** of ***established pasture.***

Fertilizer Requirements

In 1964 a large-scale pasture establishment failure prompted a series of trials at Lochinver Station, Rangitaiki. These trials investigated the effects of rates of phosphorus, sulphur, potassium, and lime on the vigour of establishing pasture. The results obtained at Lochinver were repeated at Tihoi, West Taupo (Fig. 1) and have since been adopted for use in the field.

In general, the larger the quantity of phosphate applied at sowing the greater was the vigour of the pasture. The optimum was considered to be 10 cwt/ac superphosphate (Toxopeus, 1965).

At this rate the soil P test at the Lochinver site was raised from 1 to 8; the yield of pasture was increased ninefold, compared with 4 cwt/ac superphosphate. A response to potassium was also observed. There was no response to lime.

Fertilizer Placement

In 1969, fertilizer placement was investigated in experiments at Whakatau. In one of the experiments half the plots received 5 cwt/ac superphosphate which was tine harrowed into the soil. All the plots were then sown, either by drilling the seed with 5 cwt/ac serpentine-superphosphate, or by broadcasting the seed and fertilizer on previously rolled soil.

TABLE 2: EFFECT OF FERTILIZER RATE AND PLACEMENT ON PASTURE YIELD
(lb DM/ac, spring, 1970)

	Roller Drill	*Coulter Drill*
5 cwt/ac serpentine-superphosphate	1,310	2,020
5 cwt/ac serpentine-superphosphate plus 5 cwt/ac superphosphate	2,060	2,660

TABLE 3: LUCERNE PRODUCTION FROM INCREMENTS OF PHOSPHATE, AT 20 cwt/ac LIME

***Rute* of *P at Sowing* (*cwt/ac* Super. *Equiv.*)**	*Dry* ***Matter Yields*** *(lb/ac)* ***1968-9*** (2 *cuts*)	***1969-70*** (4 *cuts*)	***1970-71*** (*4 cuts*)	***Total***	***Difference***
5	1,400	5,500	7,600	14,500	
					+ 4,000
10	2,700	7,600	8,200	18,500	
					+ 3,600
20	4,000	8,700	9,400	22,100	
					+ 1,600
40	4,600	9,200	9,900	23,700	

This trial showed two things (Table 2). First, doubling the amount of phosphate applied gave a 50% increase in yield. Secondly, the combined effects of the higher rate of phosphate application and fertilizer placement with the seed resulted in a 100% increase in yield.

LUCERNE ESTABLISHMENT

In view of the results with phosphate applications on pasture, it seemed likely that lucerne establishment should present no

TABLE 4: EFFECT OF TWO SOURCES OF COMMERCIALLY INOCULATED SEED ON NODULATION OF WHITE CLOVER

Treatment, Sown Aug. '69	Rhizobium No. Sown per Seed		Count, Nov. '69		Yields† (DM lb/ac)	
	Theoretical	Actual	Plants per sq. ft	Nodulated (%)	12/5/70	2/12/70
A	4,500	< 100	66	18	550 B	2,200 a
B*	35,000	≮ 17,000	78	87	750 A	2,300 a

*Also coated. The same kind of seed sown the following year carried < 200 rhizobia per seed, yet the clovers nodulated without deiay.

†Statistical significance by multiple range test (Duncan, 1955).

problem provided soil fertility was suitably improved. The question remained whether or not production from this crop was worth while.

In three trials, which were started at Whakatau in 1967, the requirements of lucerne (cv. Wairau) for phosphate, lime, potassium and trace elements were investigated. The seed was inoculated and drilled with 3 cwt/ac lime (Parle, 1962). Growth at first was unthrifty following a delay in nodulation of about 10 weeks.

In the first two experiments, lime at 1 ton/ac increased growth of the seedlings, and appeared to improve plant survival. There was at this stage no response to potassium or the trace elements, probably because of the lack of thrift of the plants. However, two years later growth had improved and a response to potassium, boron, and copper was observed.

The third experiment consisted of lime at nil, ½, 1 and 2 ton/ac cultivated in before sowing, and monocalcium phosphate, equivalent to superphosphate at 5, 10, 20, and 40 cwt/ac broadcast after sowing. All other elements were given as a basal application.

Yields were not measured in the first year, but an eye assessment in autumn indicated that luceme required more phosphate than pasture. One ton per acre each of superphosphate and lime produced a dense stand of vigorous lucerne. Soil samples from between the drill rows showed that the P value was changed from 1 to 8 and the pH increased from 5.0 to 5.6. At half these rates of application, the stand was very open and unthrifty and the soil showed a P test of 3 and pH of 5.2.

Production from this trial was measured over three seasons, and maintained by applying 3 cwt/ac 50% potassic serpentine-superphosphate for each cut grown, The yields confirmed the earlier observations (Table 3).

It is clear that a low initial rate of phosphate application cannot achieve a high producing stand of lucerne, even with maintenance rates considered generous by district standards.

In contrast, the production of lucerne developed from the high initial rate of 20 cwt/ac superphosphate would be considered equal to the average of the Taupo district. A further improvement in production seems possible.

NODULATION

Many reports of unsatisfactory pasture establishment have been traced to a deiay in nodulation. However, the surviving clovers would become normal eventually, and the owner of the field might shrug off the event as a "poor start".

After similar delays in nodulation, of 6 to 10 weeks, in two trials on the Rangitaiki Plateau, this aspect was investigated in a small-scale experiment with inoculated white clover, sown on the Whakatau block in 1968. It was found by Dr J. N. Parle and the writer that in the first week after sowing there were virtually no rhizobia in the rhizosphere until, in the sixth week, the population rose rapidly to 10,000 rhizobia per gram of rhizosphere soil and nodulation occurred. Where the seed had also been pelleted with lime, the initial check was overcome after 4 weeks. Thus, in addition to a protective coating, either a higher rhizobium loading on the seed or a more effective inoculum would be required.

The importance of good quality inoculum. and coating the seed was emphasized in a large-scale pasture establishment demonstration at Whakatau the following year. Although emergence was rapid, nodulation was delayed by up to 8 weeks using one commercial culture of inoculum (A), whereas seedlings from a line of commercially inoculated and coated seed (B) showed one *or* more fully grown nodules as early as the spade-leaf (unifoliate) stage. The apparent effectiveness of the inoculum used was reflected in the percentage of nodulated plants counted (Table 4).

The marked difference in yield measured towards the end of the firs season also showed the effectiveness of brand B. It was interesting therefore to find no difference in yield 7 months later. This suggests that, provided a high degree of seedling emergence and early nodulation is attained, a good deal less seed needs to be sown than is customary. It seems ironical, therefore, that the extensive studies 20 years ago by Sears et *al.* (1955), which laid particular emphasis on clover inoculation, should have been forgotten so soon.

ACKNOWLEDGEMENTS

Co-operation by the owners and managers of Lochinver and Poronui Stations, and the Land Development staff of the Department of Lands and Survey is gratefully acknowledged. I am indebted also to my own staff, colleagues, and contractors for assistance with the field work, T. S. Bailie for the rhizobium counts, and G. M. Bennett for the supply of coated seed.

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DISCUSSION

White (Lincoln College) asked whether the responses in the trials were due to P or to S or to both. Toxopeus considered that the initial response was to P as there was no response to S until the equivalent of 6 cwt superphosphate was applied. Cullen (Invermay) commented that at Te Anau it was found that lower seed rates could be used. Toxopeus agreed, saying that at Whakatau there was little difference between where 31 lb seed had been sown on the plots and only 12 lb on pathways, provided adequate fertilizer was applied. Gordon (Taupo) also stressed the need for adequate fertilizer and proper cultivation and consolidation if seed rates were to be reduced. The present cost was about $40/acre for seed, fertilizers and lime, with the latter very important for adequate nodulation. There was probably a need for a more critical evaluation of fertilizer requirements. White commented that lime coating of seed, from work in South Island, did not replace liming completely. It was most important. to get pH to 5.8 to 6.0 in order to obtain proper nodulation. Toxopeus reported that last year in the area there *were* many lucerne failures where farmers had relied on lime-coated seed rather than on applying sufficient lime.