AGRICULTURAL DEVELOPMENT OF PAKIHI SOILS ON THE WEST COAST

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Abstract

Experimental results on development of pakihi soils are presented. Coating of inoculated white clover seed had no effect on establishment or initial growth. Liming had no effect on establishment but increased initial growth. The improved lotus cultivar G4703 outyielded white clover at low rates of lime and phosphate but first-year dry matter yields were very low. The use of less soluble forms of potassium and phosphate on the low retention pakihi soils had no effect on dry matter yield. There was a useful pasture yieid response up to 75 kg P/ha but the response diminished from 30 to 75 kg P/ha. Pasture yield responses to potassium occurred up to 175 kg K/ha using the mowing and clippings returned measurement technique but only up to 25 kg K/ha where the response was measured under grazing. Elemental sulphur at 60 kg/ha significantly increased pasture yield and restored a deteriorated pasture in one trial. A simple technique based on aerial oversowing has evolved for establishing pastures on pakihi soils. Given proper management, the resulting pastures are high-producing. The conversion of grass to beef and sheep products has been demonstrated on the Pakihi Demonstration Farm near Westport and by the Department of Lands and Survey, but dairying is yet to be tested. The economy of the West Coast will be considerably enhanced by progressive development of the pakihi soils.

INTRODUCTION

THERE are an estimated 200 000 ha of pakihi soils on the West Coast of which no more than 3% have been developed for agriculture. Pakihi soils include several soil series, all gley, gley podzol or podzol soils. They are all naturally strongly acid and deficient in many essential plant nutrients. Vertical drainage is impeded because of the structureless subsoils and humus iron pans overlying cemented gravels at various depths. Because of poor vertical drainage, most of the excess water from the high rainfall (2-3000 mm per year) moves laterally on or in the surface soil into natural drainage channels.

Up to recent times, research work on pasture establishment and the fertilizer requirement of pakihi soils has been concentrated on the area near Westport where the soil is mainly the Addison gley podzol (DSIR Annual Reports, 1929-36; Easter-

field et al., 1929; Greenwood, 1964; During and Martm, 1968; McNaught and During, 1970). This research showed that oversowing of grass seed and inoculated clover seed could establish pasture if adequate lime, phosphate, potassium, sulphur, copper, and molybdenum were applied. Smith *et* al. (1976) have indicated by means of pot experimental work that fertilizer requirements in four other pakihi soils are similar.

A simple development technique based on oversowing has evolved using research results. Yield data indicate that high-producing pastures can be established on pakihi soils. The conversion of pasture to sheep and beef products is demonstrated on the Pakihi Demonstration Farm, Westport, and the Department of Lands and Survey development blocks, but dairying, which offers the best financial returns, is still to be tested. Accelerated development of pakihi soils would provide a boost to the economy of the West Coast.

This paper reports on recent research into the development of pakihi soils and describes development, objectives, management, and performance of the Pakihi Demonstration Farm, plus the wider role of pakihi development in West Coast agriculture.

RECENT RESEARCH

LIME AND SEED COATING

The original recommendation for lime for clover establishment on the Addison soil (McNaught and During, 1970) was 3.75 t lime/ha. Two recent trials (see Table 1) compared the establish-

TABLE 1: MAIN EFFECTS OF LIME AND SEED COATING

	White Clover					
	Seedling Vigour (0-5)		*Establishment. (% of viable seed)*		*Total DM Yield 1975-6 (kg/ha)*	
Site	1	2	1	2	1	2
Coating						
Not coated	3.2 bA	3.7 a	34 a	48 a	2665 a	2000 a
Coated	3.5 aA	3.8 a	36 a	47 a	2580 a	1800 a
Lime (kg/ha)						
1000	3.3 a	3.7 a	37 a	47 a	2065 bA	1770 a
3000	3.4 a	3.8 a	34 a	48 a	3180 aA	2040 a

Site 1 = Stafford (Mawhera silt loam). pH 4.5
Site 2 = Mt Sewell (Okarito silt loam). pH 4.2

ment and subsequent dry matter yield of 5 kg/ha bare seed of heavily inoculated non-coated and "Prillcote" coated Huia white clover seed in the presence of 1000 and 3000 kg/ha of lime to determine if the original recommendation could be reduced.

There was no great increase in seedling vigour or percentage of seed established between the treatments but the subsequent yield benefited from the higher rate of lime at site 1 but not site 2. Although there was no advantage from using "Prillcote" seed, it is suggested that in large-scale oversowing operations the period between inoculation and sowing, which is very critical to survival of rhizobia (Lowther and McDonald, 1973; Lowther, 1974), might exceed the safe period and it would be advisable to use coated seed in which the rhizobia will survive for a longer time when normal rates of inoculum are applied to the seed.

LOTUS SPECIES

In an attempt to reduce establishment costs, a comparison has been made of the establishment and production of three lotus cultivars developed by Grasslands Division, DSIR, and white clover at varying levels of phosphorus and lime (Table 2). *Lotus pedunculatus* has been reported to have lower requirements for lime and fertilizer than white clover on Addison gley podzol (During *et al.,* 1964; Dunne and Scott, 1964).

TABLE 2: ESTABLISHMENT AND YIELD OF LOTUS CULTIVARS
(Okarito silt loam, Mawheraiti)

	Cultivar			
	G *4712*	*c 4703*	G *4705*	*Huia*
Seedling vigour	1.9 cC	2.9 bB	*2.8* bB	*3.5* aA
Establishment (% of viable seed)	49 bB	*52* bB	*74* aA	*47* bB
DM Yield (kg/ha), 1975-6:				
P 40/lime 500 kg/ha	290 bA	1540 aA	900 abA	600 abA
P 100/lime 2000 kg/ha	735 bB	3440 aA	2500 aAB	2750 aAB

Although a greater percentage of the G4705 seedlings established, the vigour of the white clover was greater. In contrast, Lambert and Royd (1974) on a Northland podzol reported better establishment of Huia white clover than of G4703 and G4705 but the latter lotus species had the highest seedling growth rate.

Seedling vigour and establishment were not improved by the higher rate of lime or phosphate but dry matter yield was markedly increased.

Thus it appears that lime and phosphate requirements of improved *Lotus* cultivars for optimal growth on pakihi soils are similar to those for white clover.

Of the *Lotus* cultivars, G4703 appears to be the most suitable for pakihi soils, with G4712 totally unsuited, as would be expected from their respective breeding programmes. G4703 was developed by recurrent selection from *Lotus pedunculatus*, the characteristics of which include tolerance to low soil pH and poor drainage (Smetham, 1973). G4712 is an inter-specific hybrid between *L. pedunculatus* and *L. corniculatus*, the latter species being less tolerant of low soil pH and poor soil drainage than *L. pedunculatus.*

PHOSPHORUS

Form of Phosphate

Phosphate retention in pakihi soils is very low, mainly owing to the removal of aluminium and iron oxides from the topsoil by podzolization. This and the high rainfall of the West Coast could cause loss of soluble forms of the phosphate in the lateral runoff of water. Consequently, a low-water-soluble fertilizer, lime-reverted superphosphate (20% total P soluble in water), was compared with monocalcium phosphate (90% total P soluble in water) over two *years* on a developed pasture at Bald Hill (Table 3).

TABLE 3: EFFECT OF FORM OF PHOSPHATE ON DRY MATTER YIELD

P (kg/ha)	*Form*	*DM (kg/ha) 1974-5*	*1975-6*
0-1		7780 bB	4430 dC
25	Moaocalcium phosphate	8740 aA	6010 cB
25	Lime reverted superphosphate	8740 aA	6380 bcAB
50	Monocalcium phosphate	9270 aA	6820 abAB
50	Lime-reverted superphosphate	8950 aA	7100 aA

On the Addison soil (P retention 1%) there was no significant difference in dry matter yield between the two forms of phosphate in either year but a significant yield response up to 25 kg P/ha in the first year and up to 50 kg P/ha in the second year. Although phosphate retention is very low, the relatively small response to phosphate in the first year indicates a considerable residual effect of previous phosphate topdressing which de-

creases markedly in the second year. However, this trial does not compare the granule size of the two forms of phosphate which may be expected to have an effect on the rate of lateral movement of phosphate in the soil.

Phosphate Maintenance Rates

Earlier estimates of phosphate maintenance requirements for pasture on the Addison soil were 60 to 70 kg P/ha/yr (McNaught and During, 1970).

A rate of phosphate trial on the same soil has been in progress for one year. Rates from 0 to 120 kg P/ha as serpentine reverted superphosphate have been applied as split dressings and in the first year have shown a response up to 75 kg P/ha, but the main part of the response occurs up to 30 kg P/ha.

POTASSIUM

Form of Potassium

McNaught and During (1970) suggested that the soluble form of potassium as potassium chloride was rapidly lost from pakihi soils by lateral leaching. Potassium metaphosphate had been suggested as a form of potassium fertilizer which would be less liable to leaching because of its relatively immobile anion, metaphosphate. Potassium chloride and potassium metaphosphate were compared on Mai Mai sandy loam, a pakihi soil of low potassium retention. Despite theoretical advantages, the potassium metaphosphate gave no greater or longer lasting response than potassium chloride.

Potassium Mnintrnance Rates

Trials on the Addison soil indicated that maintenance rates for potassium ranged from 156 kg K/ha per annum (R. G. Smith, pers. comm.) to 190 to 250 kg K/ha per annum (McNaught and During, 1970).

TABLE 4: PASTURE YIELD RESPONSES TO POTASSIUM

K (*kg/ha*)	*DM Yield -(kg/ha)* 1973/4	1974/5	1975/6
0	6700 a	4100 dB	17oOcc
25	6690 a	5100 cB	2280 cC
100	6680 a	6630 bA	5580 bB
175	6840 a	7690 aA	7250 aA

Over the past two years on this soil, significant pasture yield responses have been obtained up to 175 kg K/ha per annum in a mowing trial where 70% of clippings have been returned (Table 4). In another trial where the response was measured under grazing, no pasture yield response above 25 kg K/ha per annum was obtained while there was a response in hogget liveweight gain up to 100 kg K/ha per annum. These results suggest that potassium maintenance rates on pakihi soils will vary depending on the measurement technique used.

SULPHUR

Sulphate can be lost very rapidly in lateral water movement on pakihi soils owing to their low sulphate retention (During and Martin, 1968).

Gypsum, even at 1000 kg/ha, is effective only for a short period but elemental sulphur at 170 kg/ha in the first two years and 21 kg/ha in the third and fourth years was sufficient to sustain relatively high pasture dry matter yields over a four-year period (McNaught and During, 1970).

TABLE 5: EFFECT OF ELEMENTAL SULPHUR ON PASTURE YIELD AND PLANT AND SOIL SLJLPHATE LEVELS

	Elemental S (kg/ha)	
	0	*60*
1974-5:		
DM Yield (kg/ha)	3660 bB	*4370* aA
Plant S (% S)	*0.20*	*0.23*
Soil S (ppm SO_4-S)	*1.0*	1.0
1975-6:		
DM Yield (kg/ha)	*3480* bB	8150 aA
Plant S (% S)	*0.25*	*0.33*
Soil S (ppm SO_4-S)	*2.8*	*6.4*

Pasture deteriorated severely on a recently developed Okarito soil at Mawheraiti and this was found to be due to loss of sulphur which had been applied solely in the form of gypsum since development. When 60 kg elemental sulphur was applied, there was a significant pasture yield response in the first year but the response was even larger in the second year (Table 5). The slow response to elemental sulphur is similar to the result of McNaught and During (1970), indicating a need to build up the number of sulphur-oxidizing bacteria in the soil. Pasture composition had

deteriorated to *Lotus pedunculatus* and Yorkshire fog under sulphur deficiency but, with adequate sulphur, ryegrass and white clover again became the dominant species.

CONCLUSIONS

The following conclusions can be drawn from the results of the experimental work. Although coating of white clover seed did not improve pasture yield or establishment, it is recommended as a safe and convenient method of inoculation. First-year dry matter yields indicate that lime and phosphate requirements of improved *Lotus* cultivars for optimal growth on pakihi soils are similar to those for white clover. There was no advantage in pasture dry matter yield in the use of potassium metaphosphate in place of potassium chloride or the use of lime-reverted superphosphate in place of monocalcium phosphate. Kesults from one year indicate an annual phosphate maintenance requirement on pakihi soils of at least 30 kg P/ha. A specific potassium maintenance requirement for pakihi soils cannot be derived from the results presented owing to the variation in the estimate of pasture yield responses to potassium between measurement techniques. The inclusion of elemental sulphur in the maintenance fertilizer application on pakihi soils every year is considered necessary owing to the short-lasting effect of sulphur applied as gypsum in superphosphate.

DEVELOPMENT PROGRAMME BASED ON RESEARCH FINDINGS

As a result of the research at Bald Hill and other experimental areas and government and private development programmes, a simple development technique has evolved for the improvement of pakihi by using aerial oversowing.

The steps involved in the development technique are:

(1) SUMMER

The area to be developed is burned where vegetation is dense. If the umbrella fern, rush and sphagnum moss are short and open, oversowing can be done directly into this cover, and no burning is necessary. Gorse on stony ridges can be sprayed at this time. If needed, roading is done, and main drains can be put in using a snow-plough or bulldozer blade, but often there is sufficient natural fall to obviate this step.

(2) SPRING

Seed, lime, and a special fertilizer mix are flown on at the following rates per hectare: Seed, 30 kg; lime, 3.75 to 5 t; fertilizer, 750 kg. The basic ingredient of the seeds mixture is Manawa ryegrass, which, given adequate topdressing and rotational grazing, tends to persist on the West Coast. A usual mixture (kg/ha) is: Manawa ryegrass, 13; Ruanui ryegrass. 5; Apanui cocksfoot, 3; Kahu timothy, 2; Huia white clover, 5; Hamua red clover, 2. Coated grass seed and coated and inoculated clover seed are recommended.

After consultation with the Ministry of Agriculture and Fisheries and the Department of Lands and Survey, Kempthorne, Prosser & Co. Ltd has formulated a pakihi development fertilizer mix containing the following (in kg/t) : Serpentine superphosphate, 928.3; elemental sulphur, 60; copper sulphate, 6.0; fertilizer borate, 5.0; cobalt sulphate, 0.5; sodium molybdate, 0.2.

(3) SUMMER

The area is fenced into small blocks using normally a two-wire electric fence to permit rotational grazing by cattle. This on-off grazing technique is the key to successful pasture establishment and maintenance. A water supply and spinner-formed drains to open up wet hollows could be extras.

(4) AUTUMN

A dressing of 500 kg/ha of 30% potassic reverted superphosphate is applied.

MAINTENANCE FERTILIZER IN SUBSEQUENT YEARS

An application of 375 kg/ha of 30% potassic reverted superphosphate containing 40 kg of elemental sulphur is recommended in spring, followed by a further 250 kg of the same mix in autumn. Liming and a return to the Pakihi Development Fertilizer is suggested every 3 or 4 years depending on soil and plant nutrient levels.

PAKIHI DEMONSTRATION FARM

INTRODUCTION

The establishment of the Pakihi Demonstration Farm at Westport was the logical step to put the research results into practice. Development began in 1966 with the oversowing of 40 ha, and

this continued first under the auspices of the then Department of Agriculture, and then under the Department of Lands and Survey, until the present area of 264 ha was completed in 1971. The farm was used for a Tb investigation for a year until 1973 when the demonstration unit in the present form began.

The farm was set up with the following objectives:

(1) To demonstrate that development of pakihi under sheep and beef farming is a paying proposition. To meet this objective initial production goals were set as below:
   (a) Cattle — achieve 90% calving to weaning.
   — produce 1.70 kg/ha of beef sold.
   (b) Sheep — achieve 90% lambing to sale.
   — produce 5.5 kg of wool per ewe equivalent wintered.

(2) To inform farmers of progress and developments in farming pakihi.

MANAGEMENT

The demonstration is a co-operative venture between the Ministry of Agriculture and Fisheries and the Department of Lands and Survey, the latter owning the land, buildings, stock, plant and machinery. Management advice and maintenance spending are provided by the Ministry. Policy is decided by a Management Committee, including two farmers, which meets at least twice a year.

LIVESTOCK POLICIES

The sheep policy in the past has been to maintain a 1200 ewe flock and a 200 cow Angus breeding herd, rearing replacements in both cases. Future policy is to increase ewe numbers to about 2400 and reduce the herd size to 75, because of the comparatively poor financial returns from a breeding cow policy. The rate of change will be determined by the availability and cost of 2-tooth ewes. A switch from the Romney breed to the Coopworth is in progress. Higher lamb and wool output is the aim.

A stocking rate of 12.4 stock units/ha will be held until stock performance improves.

A cattle-finishing policy is not considered at present because of the late onset of spring pasture growth and the 226 km dis-

tance to the nearest freezing works in Nelson. It was attempted during the first two seasons.

PERFORMANCE

Pertinent data relating to the initial goals are:

	1973	1974	1975
Lambing %	79	82	67
Calving %	78	79	82
	1973-4	1974-5	1975-6
Wool output (kg/sheep EE) ...	5.0	3.5	3.8
Beef output (kg/ha) ...	130	176	—

Reasons for the unimpressive performance to date are considered to be:

(1) Low liveweight of ewes at tupping.
(2) Unsatisfactory hogget growth rate.
(3) Unsatisfactory heifer growth rate.
(4) Inadequate maintenance fertilizer for the stocking rate.
(5) Lack of shelter.
(6) Inadequate drainage of wet hollows leading to pasture reversion in these areas.
(7) Lateness of spring pasture growth.

Closer monitoring of liveweight and its relationship with performance, planned and better feeding, lifting the topdressing rate by 125 kg/ha, and attention to shelter and drainage are all expected to contribute to a lift in farm output.

FUTURE ROLE OF PAKIHI SOILS IN WEST COAST AGRICULTURE

Results from research, from Pakihi Demonstration Farm, and from government and private development show:

(1) Pastures can be successfully established on pakihi soils using a simple oversowing technique.
(2) Resulting pastures can be high-producing. Bald Hill has recorded a 6-yearly average of 10 920 kg DM (Fig. 1) ranging from 9 970 to 11 660 (Radcliffe, 1975). But the onset of spring growth tends to be later than the pattern on most other soils.

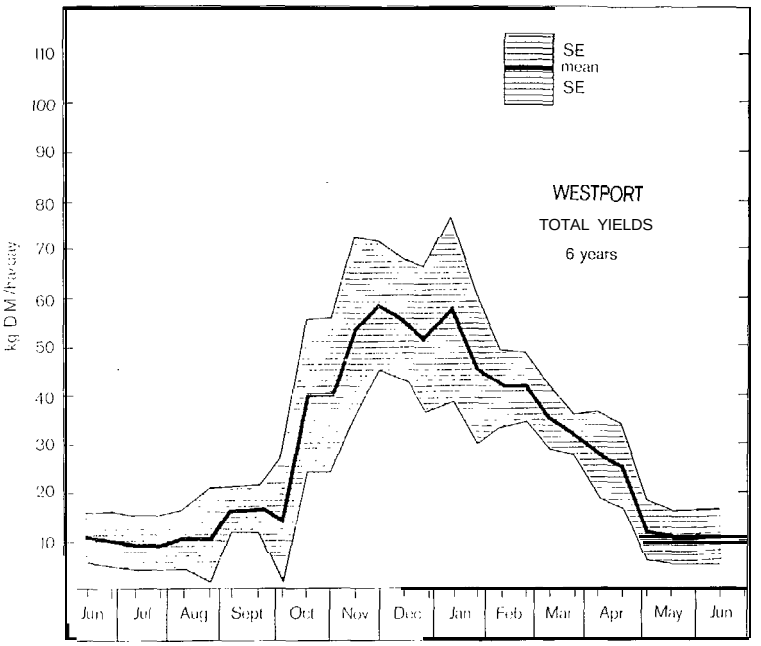

FIG. *1: Tofal yields of DM over six years at Westport.*

(3) Maintenance needs are relatively high, particularly **for** fertilizer and drainage inputs.

(4) The conversion of grass to beef and sheep products has been demonstrated, but dairying solely on pakihi is yet to be tested on the West' Coast. Private dairy farmers have developed small blocks of pakihi adjoining established units on alluvial soil.

(5) The more intensive the management applied to harvest the grass, **the** quicker the capital invested in development is recouped.

Dairying offers the best prospects for economic development of pakihi soils. This season the Department of Lands and Survey has established a dairy unit on each of its Cape Foulwind and Bell Hill blocks. The results of these ventures are awaited with interest. Not only does dairying make the economics of pakihi development more attractive, but **it** is the farming system that best fits the seasonal pattern **of** pasture growth measured at Westport.

Pakihi development is still in its infancy. At present 6000 ha of the 200 000 ha are grassed. Most of this area has been developed by the Department of Lands and Survey on its settlement blocks at Cape Foulwind near Westport, at Mawheraiti near Reefton, and at Bell Hill north-east of Greymouth.

The 1972 Land Use Capability Survey published for the National Water and Soil Conservation Organisation revealed 399 850 ha were suitable for farming on the West Coast. Half this area is in pakihi. From limited demonstration and farmer experience, it is estimated that yields of 300 kg/ha of milkfat or beef can be achieved. On current prices, these returns represent $390/ha for milkfat or $150/ha for beef. Assuming half the pakihi soils were developed equally into beef and dairying, the annual gross revenue from these 100 000 ha would be $27 million.

M. Kennedy. formerly Farm Advisory Officer, Ministry of Agriculture and Fisheries, Westport, in a report dated November 1973, estimated that within a 16 km radius of Westport there were 16 000 ha of pakihi, of which the Crown held 9000 ha. The impact of accelerated land development, whether by the Crown or the private sector, on the economy of Westport and district is obvious. The same argument holds in favour of progressive development of pakihi soils throughout the West Coast.

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