RECENT EXPERIMENTAL WORK ON PAKIHI SOILS

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THE PURPOSE of this paper is to make some general comments on pakihi soils, to review experimental work on them in the Westport district, and to make some recommendations on development techniques, based on information gained by many workers over a period of some fifty years.

The Maoris referred to *wet* clearings in the bush as "pakihi", but today on the West Coast this term is applied loosely to many wet areas -both forested and clear — and consequently includes a wide range of soils with inadequate drainage and low fertility as their only common features. This situation would be clarified if present usage of the term "pakihi" were confined to the gley podzols, thus excluding some soils commonly accepted as pakihi but which do not exhibit the degree of gleying or have not progressed to the stage of podzolization which would bring them within this classification (e.g., the Waiuta soils).

On this basis the following list of soil sets has been extracted from the legend to the general survey of soils of the South Island (*N.Z. Soil Bureau Bulletin 27*), comprising 7 of the 9 terrace soils within the hydrous sub-group of the lowland, podzolized, yellow-brown earth and podzols.

	Acres
Okarito	257,000
Kumara*	91,000
Kongahu	14,700
Addison	30:000
Omaru	2,500
Onahau	12,300
Kotinga	5,600
	413,100

* The Kumara soils now include 2,000 acres previously classified as Sergeant.

An appreciation of the differences between these soils is of importance in the interpretation of experimental work and the planning of development projects. It is suggested

that variations between sets, which are largely a matter of degree of podzolization, may be contributed to by variations in age and parent material but the major determining factor is either climate alone, bearing in mind the decreasing temperature gradient and increasing precipitation as one moves from the northern to the southern pakihis, or of climate as modified by slope where differences occur within an area of similar climatic conditions. Thus one would expect the Onahau soils of Nelson to be less leached than the Okarito of Westland; similarly, in the Westport district the gently sloping Sergeant (now Kumara) soils should rank in nutrient status above the flat Addison soils.

All pakihi soils are impoverished and possibly variations in the state of enleachment are too small to be of any significance in formulating fertilizer treatments. It is suggested, however, that these differences are due to water and, therefore, may be used as a guide to the water management required, when dealing with a particular soil.

Experiments on the Westport Pakihis

This work has been almost entirely confned to the Sergeant and Addison soils, with emphasis on the former from about 1906 to 1939 and on the latter in more recent years. Aston, a chemist with the Department of Agriculture, carried out the first recorded investigation of pakihi in 1906 and on the basis of pot tests concluded that heavy dressings of lime and basic slag were required. The Cawthron Institute, assisted by grants from local bodies, initiated the first intensive investigation in 1912 and encouraging results saw development extended by the Lands Department and the Small Farms Board during the 1930s. By 1938, a total of 1,400 acres had been grassed and dairying was established on 100 acres carrying 35 cows averaging 200 lb of butterfat per head. About 400 beef cattle were grazed on the balance of the grassed area. In 1939, the development project was abandoned, owing to a combination of factors — the outbreak of war, a shortage of labour, and the deterioration of pastures under cattle grazing. The land was leased to adjoining farmers initially on a year-to-year basis, but more recently on a five-year term with right of purchase.

Meanwhile, in 1930, the Department of Agriculture attempted to apply the development techniques used at Sergeant's Hill to a 160 acre block of Addison soil at Bald Hill. A total of 60 acres was grassed, but in 1934, when feed was inadequate for the 25 dairy cows carried, the project was abandoned. It is interesting: to note that, on this site,

pastures have reverted to fern and "pakihi" rush, whereas on the Sergeant soils there are still grasses of the lower fertility-demanding species present.

Experimental work on the Bald Hill site was revived in 1952 when an area of approximately three acres was ringed with surface drains to eliminate the inflow of surface water. The block was then ploughed, sown with a mixture of ryegrass and white clover, and treated with 1 ½ tons of lime and 6 cwt of serpentine superphosphate per acre. The area could not be fenced until the following year, by which time it had deteriorated as a result of unrestricted grazing by wandering cattle. In 1954, a portion of the original trial was reploughed in narrow lands to aid surface drainage and sown to' a mixture containing Yorkshire fog and *Lotus major* with a further application of 1 ton of lime and 1% cwt of double superphosphate per acre. The initial ploughing was accomplished with extreme difficulty, using a crawler-type tractor. The second ploughing also proved difficult but was completed with a wheel tractor, illustrating that there had been a substantial change in physical condition following cultivation.

Over a period of 10 years this block has received 5 ½ tons of lime, 4 cwt of muriate of potash, and the equivalent of 15 cwt of superphosphate in the form of double superphosphate and serpentine superphosphate per acre. Soil test figures have changed from a pH of 4.5 and calcium of 2 to pH 6.2 and calcium of 9 ; potash and phosphate figures have similarly increased- potash from 3 to 8, and phosphate from less than 1 to 9.

In 1961, a surface drainage system was successfully installed on an adjoining 2½ acres which were cultivated, graded into "humps and hollows" and sown with two seed mixtures — one predominantly Yorkshire fog and *Lotus major,* the other ryegrass and white clover. At the same time, a further area of 2 acres was burnt and oversown with similar seed mixtures. Fertilizer treatments on both areas included dressings of 1 and 2 tons of lime, 4 and 8 cwt of superphosphate and 0, 1 and 4 cwt of potash.

Further large-scale and plot treatments have been applied to both these areas, embracing major and minor elements, the pelleting and inoculation of seed, and species trials; even the growing of rice has received some attention.

One important feature of the management of these trials is that they have been grazed by sheep rather than by cattle as in the pre-war series of experiments.

On the basis of successful plot experiments conducted by C. During, a 40 acre block of pakihi was fenced and oversown in the autumn of 1964. This area was sown in ryegrass and white clover and treated with 1 ton of lime and 6 cwt of superphosphate containing 2½ oz of molybdenum and 10 lb of copper sulphate per acre.

Conclusions to be Drawn from Experiments

The response in terms of pasture production to applications of lime, superphosphate and potash at varying rates and combinations has not been marked. There has been, as would be expected, a tendency for *Lotus* major/Yorkshire fog dominance at lower levels and perennial ryegrass, Yorkshire fog and white *clover/Lotus major* associations at higher levels of topdressing. The inclusion of copper and molybdenum, however, resulted in a luxuriant growth of white clover and presented a picture which would warm the heart of anyone familiar with pakihi. Undoubtedly, other deficiencies will become apparent with time and will present problems in pasture maintenance.

Yorkshire *fog/Lotus major* has so far produced a denser pasture than ryegrass/white clover and is, therefore, more suited to winter stocking, although it is less palatable in the summer months. Trials carried out in association with R. M. Greenwood have shown that inoculation is necessary with white clover but does not appear to be necessary with *Lotus major.*

In 1920, C. S. Dalgleish, a Fields Instructor of the Department of Agriculture, claimed that surface drains would provide the only satisfactory method of draining pakihi. All subsequent work has confirmed this opinion. Surface drainage in the form of "humps and hollows", has proved very successful but a practical technique of constructing these in native pakihi has not yet been developed. It is suggested that, in the initial development of pakihi, drainage could be restricted to the opening up of natural waterways and the provision of a herringbone system of surface drains. The intensity of the drainage system required would be influenced by the amount of natural fall available. The installation of a more efficient system such as "humps and hollows" would then be delayed for a few years until the area was cultivated prior to sowing down for the second time.

Work at Bald Hill has confirmed that it is not necessary to cultivate to establish a pasture and it is considered that,

in initial development, cultivation should be adopted only where some degree of surface forming is required as an aid to drainage.

Damage to pasture during grazing has been minimized by the use of sheep and no problems have been experienced with these animals, although routine drenching procedures have been followed and cobalt bullets administered, as a precautionary measure.

Recommendations

(1) Open up natural depressions with V-drains to provide an outlet for surface runoff.

(2) Burn thick stands of scrubby manuka, though burning is not necessary on open clearings.

(3) The following mixture should be sown in either spring or autumn:

10 lb perennial ryegrass
5 lb Yorkshire fog
3 lb cocksfoot
3 lb timothty
½ lb crested dogstail
1 lb *Lotus major*
2 lb white clover

(4) Play safe and inoculate all legumes .

(5) Apply per acre 1 to 1½ tons lime, 6 cwt of serpentine superhosphate, 2 oz molybdenum and 10 lb of copper sulphate.

(6) Sow fertilizer first and then follow with the seed about 2 days later to avoid germination injury.

(7) Topdress six months later with up to 2 cwt potash and 3 cwt superphosphate.

(8) Graze with sheep only and remember cobalt is a likely deficiency.

(9) Selected areas can later be formed into "humps and hollows" to become grass harvesting areas. At that stage, the stocking rate can be increased from 2½ ewes per acre under extensive set stocking, to as high as 4 ewes per acre under mob stocking.

(10) Future fertilizer maintenance will be at a minimum of 3 cwt of superphosphate and 1 cwt of potash per acre per annum and 1 ton of lime every four or five years. It is possible that molybdenum will be required every four years and 5 lb copper sulphate every year.

Present indications are that additional sulphur and some iron might also be required.

The West Coast climate breeds a spirit of optimism which may be reflected in this paper. At the least, the present outlook is a little brighter than A. H. Cockayne's, who in 1927 wrote: "When one is inundated with letters and reports on the huge prospective value of pakihi lands, one is inclined to become jocular. It rains 182 days in the year, taking another 182 to dry up, leaving 1 day to work and a one hundred per cent. increase in leap year."

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JOINT DISCUSSION

Has a spinner-type drainage machine been tried on this soil type?

MR **SCOTT:** Only very limited use has been made of one of these machines because our tractor is underpowered for this work. It is intended that a more powerful tractor will be purchased and extensive trials carried out with the spinner type machine.

Has mole drainage been tried?

MR SCOTT: Yes-quite unsuccessfully. The greatest limitation to this type of drainage is imposed by the shallow depth to the pan.

Would open drains lower the water-table, given sufficient time?

MR SCOTT: Deep, narrow, open drains excavated some thirty years ago on experimental sites have not had any beneficial effects on the adjoining pakihi. The tyve of drainage now advocated incorvorates channels which could be technically termed open drains but they are of a shallow surface type and their purvosc is to remove surface water and not control ground water levels.

How much sulphur is lost through leaching? Was gypsum lost more quickly than elemental sulphur?

MR **DURING:** Sulphur moves sideways. We have not yet calculated the proposition of applied gypsum lost this way, but it is likelv to be very high. From indirect evidence, using placed analytical data, it would seem that gypsum is lost more rapidly than sulphur.

***Are high rates of lime affecting the** sulphur response? In. some ureas **high rates of** lime **produce** a **manganese deficiency which prevents a** sulphur response.*

MR DURING: We have not seen lime-induced manganese deficiency, but have not used more than 3 tons of lime per acre. At this rate of application we get excellent growth which could be expected to accentuate sulphur deficiency.

***Have any investigations been carried out on depth of oxygen penetration und could this account for some of the benefits of deep cultivation used by** MY O'Loughlin?*

MR CHITTENDEN: No. My investigations have been with pakihi soils in Golden Ba ay. Here it is unnecessary, in fact, undesirable, to cultivate deeply. igh grade pastures are obtained by shallow cultivation or surface sowing after burning off scrub.

Have split applications of** sulphur **been considered in view of the** large **total amounts used?

MR CHITTENDEN: Yes. We are now using all our fertilizers in split applications. No measurements of yield benefit from this method have yet been taken, but soil analyses show rapid leaching of fertilizers on these soils and it is for that reason that split applications were adopted.

*How bad **is the effect of overburning on these soils? Is it a disadvantage?***

MR DUNNE: Burning can occur at any time of the year because the pakihi rush is naturally high in oil and with a breeze a fire can spread rapidly. The N.Z. Forest Service are naturally concerned, and from their point of view fires are not good for regeneration if this ever occurs. For a farmer fires bring on fresh young growth which is more acceptable to stock and I doubt that agriculturally they cause much damage.

Have research workers exhaustively experimented with drains** other **than surface?

MR DUNNE: We have tried mole, tile and open drains. Mole drains collapse, tiles block and become cemented to the pan, and open drains fail to draw water from the surrounding soil. We prefer surface drainage with some open drains to collect and channel away surface water.

***Have any experiments been done with cultivation to remove** sphagnum moss?*

MR DUNNE: We have cultivated, but for cheapness, oversowing is better, provided one uses V-drains to remove surface water and therefore the main cause of sphagnum. In other words, V-drain wet sphagnum areas, and gradually the moss will disappear.

What are** MY **Dunne's costs?

MR DUNNE: I estimate initial costs at about £15 per acre, not counting fencing and stock, etc.

How fur apart does** MY Dunne **dig open drains?

MR DUNNE: We have dug bulldozed drains to the pan at varying intervals apart from one-half chain up to 3 chains.