COULD MODIFYING THE PAKIHI SOILS IMPROVE PRODUCTIVITY?

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Introduction

Pakihi soils (Gley podzols) constitute a significant proportion of the pastoral land in Golden Bay, some 5300 ha, the majority of which is farmed. Contained within this area is the Aorere Valley, terminating at the river mouth in the township of Collingwood. In the 1960's the NZ Soil Bureau had previously determined phosphate retention (or anion storage capacity, ASC) on Pakihi soils at 1:50000 scale as having typical ASC levels of around 2%. (Onahau Soil, Humose Perch-gley Podzol 2% ASC) (Anon, 1968).

The low ASC, coupled with annual rainfall in the Aorere Valley which ranges from around 2200 mm at the coast up to 5000 mm at the upper reaches of the farmed area has meant that under these conditions the soil Olsen P levels have been difficult to raise to optimise pasture production and subsequently to maintain Olsen P levels. Coincidentally, local regional council measurements on one stream that has an effective catchment of this pastoral Pakihi land had median dissolved reactive phosphate measurements (from nine samples taken between July 2004 to November 2011) significantly above ANZECC guidelines. (James and Mullis, *In press*). This paper investigates these particular pakihi soils and discusses potential strategies for improving productivity.

Investigation and Results

In 2012, utilising samples undertaken during regular soil fertility monitoring, a detailed survey of ASC levels from farms within the Aorere Valley was conducted. The samples were sent to the ARL laboratory for standard ASC (Phosphate retention) testing. Samples were shaken for 16 hours in a 1000 mg/L P solution, and after clarification of the extract, the phosphorus left in solution was determined colorimetrically. The phosphorus retained by the soil is calculated by difference and expressed as a percentage of the total (Blakemore et al. 1987).

The distribution of these ASC levels across the Aorere Valley is shown in Figure 1. The Pakihi soils (typically classified as Onahau) had ASC levels typically below 10, while the brown and recent soils in the river basin had higher ASC levels (ranging from 20 to 68).

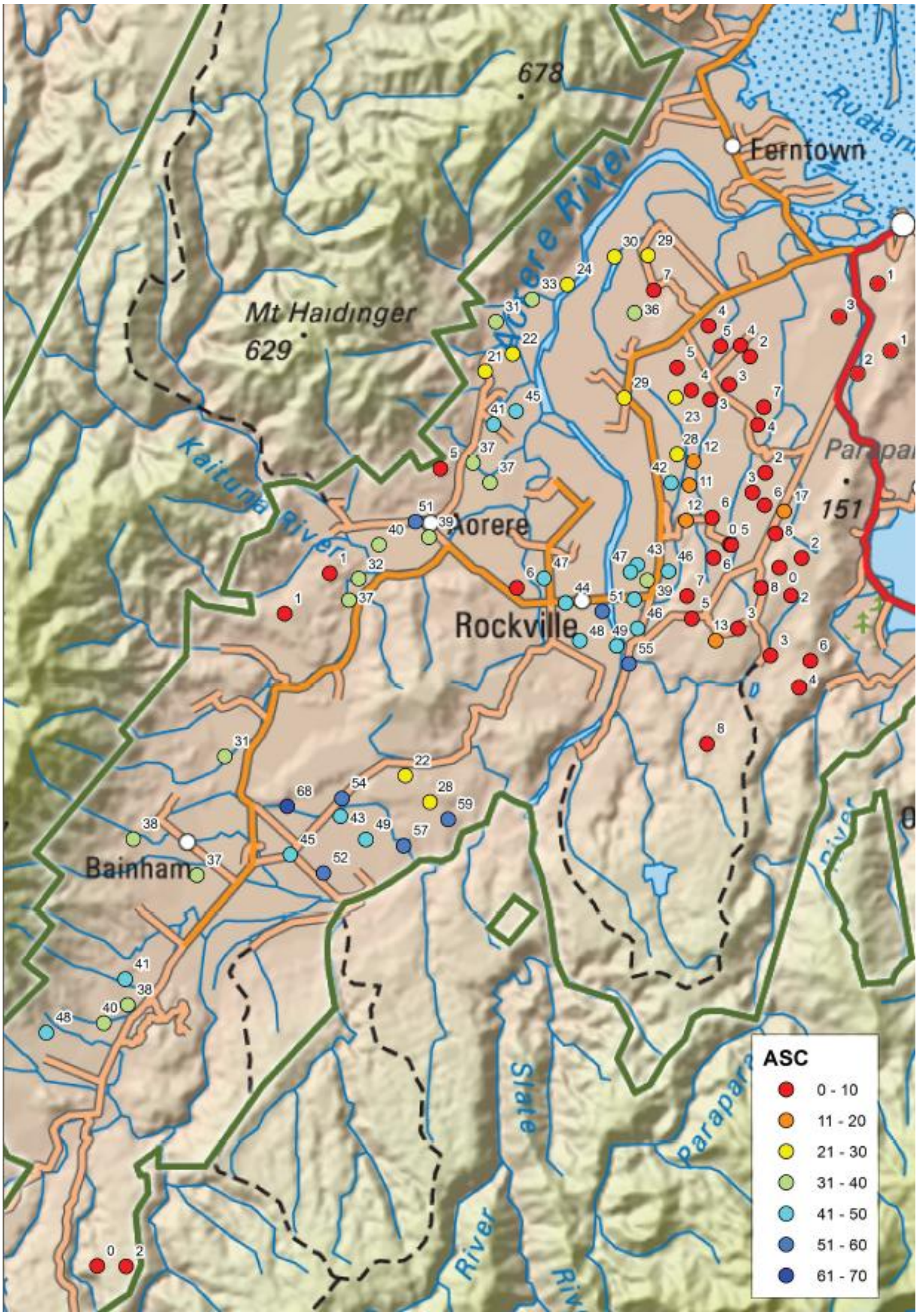


Figure 1: Distribution of ASC levels throughout the Aorere Valley

At each end of the Valley a pit was excavated to a depth of 600 mm, with the profile sectioned at 75 mm intervals. The upper layers (from 0 cm to 300 mm) of the profiles were predominantly silica sands and recent sediments, while lower in the profile a higher content of clay was observed indicated by the yellow and orange mottling (Figure 2). The highly consolidated surface layers appeared to have minimal macropores, but this was not quantified.

Figure 2: Soil profile pits showing differing composition with depth (Pit 1 on left, Pit 2 on right)

Both pits have darker topsoil layers, which is due to the organic matter accumulation from plant and animal residues over time. Below the darker topsoil is a consolidated sandy textured layer. Below this in pit 1 (the northern pit) a diffuse layer of increased mottling is apparent. In pit 2 (the southern pit) there was an obvious iron pan below which the soil becomes more clay-like in texture (and was exceedingly sticky).

Pit 1 (Table 1) was under a rainfall of 2900 mm, on a slope less than 5 degrees. In contrast, Pit 2 was under an annual rainfall of 4200 mm and a slope of about 10 degrees (Table 1).

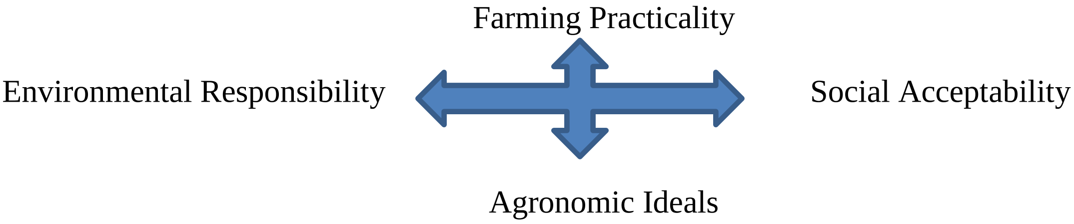
PIT ONE			**PIT TWO**	
	S40.69823^{o}	Latitude	S 40.81624^{o}	
	E 172.67540^{o}	Longitude	E 172.54150^{o}	
	5 degrees	Slope	10 degrees	
	45 m	Elevation	230 m	
	2925	Av Rainfall (mm)	4240	
Olsen P	**ASC**		**ASC**	**Olsen P**
7	3	**0 – 7.5 cm**	1	18
2	1	**7.5 – 15 cm**	<1	7
<1	2	**15 – 22.5 cm**	2	5
<1	4	**22.5 – 30 cm**	3	11
1	13	**30 – 37.5 cm**	18	22
11	50	**37.5 – 45 cm**	52	9
4	61	**45 – 52.5 cm**	64	3
<1	62	**52.5 – 60 cm**	67	2

Table 1: ASC levels by depth in observation pits on pakihi soils of the Aorere Valley

The ASC levels in the upper 4 depth intervals in both pits are low, with organic matter mixed with mineral material in the top 2 intervals and leached silica sand as the predominant material in the next 2 intervals. As the colour intensifies (due to accumulation of iron, aluminium and manganese oxides) along with the increasing clay content so too does the ASC. In both pits as the ASC level increases there is a corresponding increase in Olsen P levels. Less total phosphorus has migrated down the profile in pit 1, although as a proportion this is greater than in pit 2, with over 60% in the bottom 4 intervals in pit 1 compared to 46% in pit 2.

Discussion

Productivity is difficult to maintain on these soils and with the increasing environmental awareness, and measured effects in the environment, the on farm fertiliser regime requires more consideration.



At some juncture between these four points the on farm decision is made. This point differs on each farm as different weightings are placed on each individual aspect. At the field level this means that there are two approaches for the farmer to improve phosphorus efficiency in the paddock in relation to farm productivity. These are to modify the soil or to modify the practice.

Mitigation and modification options, improving agronomic effectiveness of nutrients and sustainability all inherently go through the same decision making process, where each of these points are weighted. For example, McDowell (2012) suggests targeting P loss mitigation strategies to the areas that lose the most P (critical source areas), but that constitute little of the farm catchment area, this maximises the environmental and social sides without large impacts on farming practicality and agronomic ideals. The difficulty in adopting this strategy to the Pakihi soils of the Aorere Valley is that due to the high total rainfall, intensity of rain events and slope of the Pakihi terraces that all areas will contribute to the catchment area over the time. Overland flow will enter stream edges at any point, completely overwhelming filter strips, as was found by Buda (2012).

Modifying the soil

Flipping

Flipping arises as a potential strategy as from the soil pits dug in the Aorere valley the ASC levels at 600 mm depth were in both cases more than 20 times greater than at the surface. As such if flipping was undertaken, and assuming a reasonable mixing of the soil occurs it is potentially feasible that the ASC level may be altered in Pit 1 from 3% to 25% in the top 7.5 cm and from 1% to 26% in Pit 2. The issue that arises is that the column of soil is completely disturbed and potential erosion risk increases, so as a soil modification strategy would be most feasible on soils with aspect slope of less than 8 degrees.

Claying

In Australia this is a modification carried out on the sandy soils of Western Australia. Clay high in metal oxides is brought in and mixed with the topsoil to increase both moisture and nutrient retention properties of the sand. McDowell (2012) had looked to use Alum and red bauxite amendments to grazed pastures which would have a measure of effectiveness, but may be costly per kg of phosphorus conserved. For the practicality of this modification to be realised, a locally sourced, high ASC material which is inexpensive must be found.

Modifying the practice

Fertiliser form is also an important loss factor with RPR determined to lose less phosphate than soluble forms such as superphosphate or DAP. When modelled through Overseer, reductions in phosphate have been achieved ranging from 3 -30%. Where slope is between 0-8 degrees the increased reduction in runoff losses are greater, however the overall losses are significantly lower. As the slope increases so too does runoff.

Under the climatic conditions in the Aorere Valley most existing fertiliser plans have N, K and S split up to 8 times throughout the season. Capitalising on this spreading frequency, phosphate inputs have been recommended split and applied at lower rates more often lessening the runoff risk factors of the soluble fertiliser and capitalising on the on farm infrastructure (as many of the dairy farms have on farm fertiliser silos, capable of storing high analysis fertilisers).

Although P loss from the soil accounts for 40% of the surface runoff, McDowell (2007) identified the pasture component as contributing 20% of the P loss in surface run off. Quite often Pakihi soils revert back to more native type pastures much faster than other sedimentary soils. Fertility will be an aspect, but also where these soils are above field capacity for considerable periods then pasture species will die off. Pasture species selection therefore may also be beneficial in reducing the P loss. Pasture quality and palatability may be reduced if cocksfoot is utilised as pasture species, and according to a Cropmark Agronomist (*pers comm*) it is a grass that has a better ability of surviving a soil environment that goes from dry to waterlogged rapidly.

Conclusion

The overall aim of this paper was to investigate if there are any potential modification practices open to the farmers of the Aorere valley, who farm pakihi soils. Whilst in theory there are modification options available, such as flipping or claying the soils and McDowell (2012) gives the environmental benefits of some modification techniques, these have yet to be determined against the farming practicality and financial cost of modification. Until further research has been conducted at farm scale the most appropriate approach is to modify the farming practice, which in many cases requires no additional financial input.

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