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COST-BENEFIT ANALYSIS OF CADMIUM MANAGEMENT IN NEW ZEALAND'S HORTICULTURAL SOILS

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Introduction

New Zealand's horticultural industry is currently undergoing rapid expansion with exports recently reaching $4.3 billion (Plant and Food Research, 2015). Cadmium (Cd) accumulation in horticultural soils as a result of the widespread repeated application of phosphatic fertilisers is one risk faced by this industry; if foodstuffs exceed international food standards for Cd market exclusion can occur. Cadmium phytoavailability depends on soil and crop factors with soil pH and organic matter content being two key drivers. At a high soil pH there is increased competition with Ca^{2+} for plant root exchange sites while higher organic matter content increases Cd adsorption and complexation (Adriano, 1986; He & Singh, 1993; Roberts, 2014). New Zealand's current Cd management system, the Tiered Fertiliser Management System, fails to account for soil and crop specific factors, and as such, a risk-based system is required to cater to New Zealand's diverse range of horticultural environments. A mitigation strategy utilising lime and compost amendments to increase soil pH and organic matter content is currently undergoing field trials at three New Zealand field sites (Pukekawa, Manawatu and Lincoln), with the aim of regulating Cd bioavailability in soils used for potato production. The objective of this study is to determine the economic viability of the use of compost and lime for regulating Cd bioavailability in soils under potato production.

Assumptions and Cost-Benefit Model in this Study

This analysis is based on a 50 ha commercial potato plot in each location. This analysis assumes that if Cd residue levels in potatoes exceed international food standards, 100% of the yield will be rejected by markets and thus all revenue lost. However, if the mitigation is applied, yield and revenue will be protected. Farmgate potato prices have been used rather than export prices to quantify the costs and benefits at the farm-scale. A one-year projection period was used as the longevity of the soil amendments is as yet unknown. A discount factor was not used due to the short projection period of this analysis.

Costs of mitigation implementation ($X) and benefits from potato revenue ($R) were quantified for each field site (refer to Table 2) based on the assumptions and values presented in Table 1. Two pH targets of 6.4 and 6.8 were used for each site to determine lime application rates through initial pH incubation experiments (Thompson-Morrison, 2017). Equation 1 was used to determine the expected net return (ENR) from mitigation of 100% yield rejection.

$$\text{ENR} = \$R - \$X \qquad \text{(Equation 1)}$$

Table 1. Factors considered within the CBA and their associated values

Factor		Value
Potato yield (Potatoes NZ Inc., 2015)		60 t/ha
Potato farmgate revenue (Askin & Askin, 2014)		$280/t
Aglime requirement pH 6.4	Pukekawa	3.90 t/ha
	Manawatu	6.26 t/ha
	Lincoln	7.70 t/ha
Aglime requirement pH 6.8	Pukekawa	9.10 t/ha
	Manawatu	11.07 t/ha
	Lincoln	12.52 t/ha
Aglime supply and cart rate (C. Telfer, personal communication, November 24, 2016)	Pukekawa	$42 + GST/t
	Manawatu	$36 + GST/t
	Lincoln	$45 + GST/t
Aglime spreading rate (Askin & Askin, 2014)	Pukekawa	$18.61/t
	Manawatu	$17.38/t
	Lincoln	$17.38/t
Compost requirement (Horrocks et al., 2013)		25 t/ha
Compost cost (G. Wright, personal communication, November 22, 2016)		$12.50 + GST/t
Compost spreading rate (G. Wright, personal communication, November 22, 2016)		$8.00 + GST/t
Compost transport rate (G. Wright, personal communication, November 22, 2016)		$4.25 + GST/km

Table 2. Costs of mitigation and revenue from farmgate sales with current yields maintained at 100%

	pH Target	Year	Benefits	Total Benefits ($'000)	Costs				Total Costs ($'000)
			Farmgate Potato Sales ($'000)		Lime Supply & Cart ($'000)	Compost ($'000)	Compost Transport ($'000)	Spreading ($'000)	
Lincoln	6.4	0	0	0	19.93	17.98	0.14	18.19	56.24
		1	840	840	0	0	0	0	0
	6.8	0	0	0	32.39	17.98	0.14	22.38	72.89
		1	840	840	0	0	0	0	0
Manawatu	6.4	0	0	0	12.95	17.98	2.50	16.94	50.36
		1	840	840	0	0	0	0	0
	6.8	0	0	0	22.91	17.98	2.50	21.12	64.51
		1	840	840	0	0	0	0	0
Pukekawa	6.4	0	0	0	9.42	17.98	0.30	15.13	42.83
		1	840	840	0	0	0	0	0
	6.8	0	0	0	21.98	17.98	0.30	19.41	59.67
		1	840	840	0	0	0	0	0

Results

In every scenario the ENR from mitigation was greater than $0. Thus this strategy is economically viable at the farm-scale at a pH of both 6.4 and 6.8 at every site as shown in Table 3. The difference in ENR between pH 6.4 and 6.8 at each site averages $15,875.53 with pH 6.4 producing a more profitable return at each site due to the lower amount of lime needed to adjust the soil pH to this value.

Table 3. Expected Net Return from mitigation based on target pH and 100% yield protection from market rejection at each site

	pH Target	**Expected Net Return from mitigation ($)**
Lincoln	6.4	783,756.70
	6.8	767,116.42
Manawatu	6.4	789,637.47
	6.8	775,492.66
Pukekawa	6.4	797,171.02
	6.8	780,329.53

Limitations

There are several limitations to this analysis: The longevity of soil amendments is as yet unknown, thus costs and benefits beyond year 1 cannot be quantified – this limits the efficacy of the analysis as over an extended time-period it is likely that costs will be reduced and thus the strategy's ENR will change. Furthermore, raising soil pH to >6.0 risks the development of potato scab which has potential to have negative outcomes for potato revenue.

Conclusions

Over an initial one-year projection period, the proposed Cd mitigation strategy utilising lime and compost amendments to increase soil pH organic matter content is economically viable at the farm-scale and may be considered for implementation in areas where soil Cd concentrations pose risks to horticultural exports. It is possible that over an extended time the ENR may change. Further research on the longevity of soil amendments and their ongoing benefit in regulating Cd bioavailability will be valuable in determining the long-term economic efficiency of this strategy

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Personal Communications

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