Journeaux, P.R., 2018. Economic benefit of reducing the coefficient of variation of fertiliser application. In: *Farm environmental planning – science, policy and practice*. (Eds L. D. Currie and C. L. Christensen). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 31. Fertilizer and Lime Research Centre, Massey University, Palmerston North, New Zealand. 9 pages.

ECONOMIC BENEFIT OF REDUCING THE COEFFICIENT OF VARIATION OF FERTILISER APPLICATION

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Abstract

This analysis investigates the economic impacts of varying the coefficient of variation of fertiliser application (CV - essentially the evenness of the spread of fertiliser), and its subsequent impact on farm profitability. It is based on published research relating CV to changes in pasture DM production, which was used to model a representative North Island Hill Country sheep & beef farm and Waikato/Bay of Plenty dairy farm, within Farmax.

Subject to the assumptions made, the results showed, that for a representative North Island hill country sheep & beef farm, increasing CV's above 40% had an impact on dry matter production and subsequently on farm profitability.

Similarly, for the representative Waikato/BoP dairy farm, increasing CV's above 50% had an impact on dry matter production and subsequently on farm profitability.

While the impact on total DM grown was not large, it was the seasonal variation that had a greater overall impact. There is also an inference that increasing CV's have a larger impact at lower fertility levels (or conversely a lower impact at higher fertility levels).

Background

The analysis is based on applying research results (discussed below) as to the impact of varying CV's on dry matter production and then modelling the impact of this variation in dry matter production through Farmax models of a hypothetical farm representative of North Island Hill Country and of Waikato/Bay of Plenty dairying.

In the absence of good information, a number of key assumptions are made, which are discussed in the paper.

Background Research Results

The key research paper used in this analysis is *Fertiliser evenness – losses and costs: A study on the economic benefits of uniform applications of fertiliser* by Horrell et al (Grasslands 1999)[1], who indicated a loss of pasture DM growth relative to the CV of fertiliser application.

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[1] Horrell, R., Metherell, A.K., Ford, S., Doscher, C., (1999) *Fertiliser evenness – losses and costs: A study on the economic benefits of uniform applications of fertiliser. Proceedings of the New Zealand Grassland Association 61:215–220*

This is shown in Table 2 of the paper:

Table 2: **(from *Horrell et al*) Yield loss (kg/ha) for a range of six CV levels and five farming scenarios (average for all spread pattern types).**

Crop/Fertiliser	CV LEVELS					
	10%	20%	30%	40%	50%	60%
Canterbury Ryegrass Seed - N	1.4	6.2	16.6	32.2	59.8	89.1
Waikato Pasture - N	1.3	5.7	12.6	21.5	38.2	54.5
Waikato Pasture - P&S*	1.6	7.0	22.7	51.1	117.1	277.0
Southland Pasture - P&S*	2.9	11.1	26.4	45.0	70.2	100.3
Hawke's Bay Pasture - P&S*	6.3	28.3	57.7	110.4	170.6	239.1
*Results for Year 3 only						

The above figures are based on:

(i) Canterbury Ryegrass seed; modelling based on experimental results from an irrigated site

(ii) Waikato Nitrogen; modelling based on small plot mowing trials

(iii) Waikato Phosphorus and Sulphur; Modelling in Outlook based on ground spread superphosphate on a Waikato dairy farm (Olsen 25, organic S 10)

(iv) Southland Phosphorus and Sulphur; Modelling in Outlook based on ground spread superphosphate on a Southland S&B farm (Olsen 18, organic S 10)

(v) Hawkes Bay Phosphorus and Sulphur; Modelling in Outlook based on aerial application of superphosphate on a HB S&B farm (Olsen 10, organic S 5).

A key assumption for this analysis is that the above reduction in DM production represents the "field" situation, representing the (lack of) evenness of spread of fertiliser at a paddock level, which incorporates the range of factors which influence evenness of spread, e.g. aircraft height and speed, wind, hopper performance, and flow characteristics of the fertiliser.

For the purposes of this analysis, the "Waikato pasture - Phosphorus & Sulphur" figures from *Horrell et al* were used in a Waikato/BoP dairy farm simulation, and the "Hawke's Bay - Phosphorus & Sulphur" figures from *Horrell et al* were used in a North Island Hill Country simulation.

Methodology

Hill Country Model

The North Island Hill Country model farm used in the analysis is based on a weighted average of Beef+Lamb NZ's Class 3 North Island Hard Hill Country, and Class 4 North Island Easy Hill Country; specifically, 22% Class 3, and 78% Class 4, based on the number of farms in each class.

This gives a farm of 511 effective hectares, running 1,993 breeding ewes, and 131 breeding cows, finishing most stock (further details in Appendix 1).

The model is also divided as to topography, again based on Beef+Lamb NZ statistics, namely; Flat 10.3%, Rolling 45.3%, Steep 44.4%.

The pasture growth curve used in Farmax was based on the Central North Island (medium quality) growth data, with a total DM production of 6.64 tonnes DM/ha/year. This was further modified between the topographical split, namely:

Table 1: Dry Matter Production by Topographical Category (kgDM/ha/yr)

	Flat	Rolling	Steep	Weighted Av
% change relative to the Farmax growth curve	165%	115%	70%	
kgDM/ha/year	10,940	7,625	4,641	6,644

Pasture Growth

A further key assumption was to turn the absolute DM production losses for the Hawke's Bay pasture into percentage losses, as applied to the hill country situation.

Table 2: Percentage Reduction Relative to CV (S&B)

CV Levels	Actual DM Reduction (Horrell et al – HB S&B) kgDM/ha	% change in NI Hill Country DM growth
10%	6.3	0.1%
20%	28.3	0.4%
30%	57.7	0.9%
40%	110.4	1.7%
50%	170.6	2.6%
60%	239.1	3.6%

The percentage reduction was then applied to the Hill County model, relative to the monthly pasture production by topographical area (Ref Appendix 2). Within the model the main "pinch" period for pasture supply/demand was in September/October (i.e. lambing/calving), and again to a much lesser extent in April/May heading into winter. This is important as any pasture growth reductions during these periods can have a disproportionally large impact on the whole farm system.

The modelling therefore involved reducing pasture growth by the percentage relative to the CV, and then adjusting the model to achieve a feasible solution. The easiest way to achieve this was to scale down capital stock numbers, rather than try and adjust stock performance for the different groups at different times of the year. In essence therefore, capital stock numbers were reduced (with all other stock numbers reduced proportionally), while stock performance, slaughter weights etc., were left the same as for the base model.

Dairy Model

The dairy model used in the analysis is based on the average farm for the Waikato and Bay of Plenty Regions, based on Livestock Improvement and Dairy NZ statistics, and operating a System 3 farm system.

This gives a farm of 123 hectares effective, wintering 367 milking cows, producing 139,500 kg of milksolids (further details in Appendix 1). The base pasture growth curve used produces 13.0 Tonnes DM/year.

Pasture Growth

Again the methodology involved translating the absolute decreases in pasture growth from Horrell et al into percentage figures, as illustrated below.

Table 3: Percentage Reduction Relative to CV (Dairy)

CV Levels	Actual DM Reduction (Horrell et al – Waikato dairy) kgDM/ha	% change in Waikato/BoP dairy DM growth
10%	1.6	0.0%
20%	7.0	0.1%
30%	22.7	0.2%
40%	51.1	0.4%
50%	117.1	0.9%
60%	277	2.1%

As per for the hill country model, the percentage change in pasture growth was applied to the monthly pasture growth within the Farmax model, with the main "pinch" period being through October – December. Assuming the CV resulted in a feed deficit through this period, milk production was reduced (to reduce demand) until the model showed a feasible solution. Stock numbers were left unchanged.

Results

Hill Country Model

CV's less than 40% showed minimal/zero impact on the model. At 40% and above, an increasing level of impact was recorded[2].

[2] Note that the 40 % CV for paddock scale CV is not the same as the Spreadmark CV requirement for a truck to be at 15 % CV. Spreadmark requires an approved spread pattern for trucks as follows: "*by an Approved Spreading Equipment Tester that the fertiliser application equipment has been tested and the track spacing (bout width) required to achieve a CV% of 15 for nitrogenous fertiliser and 25% for all other products has been shown"* (i.e. the truck might have an approved spread pattern but if the driver is all over the place with large areas missing or large gaps in the field, this will affect the paddock scale CV; the Spreadmark CV is not relevant.) http://fertqual.co.nz/understanding-the-marks/spreadmark/

Table 4: Impact on Stock Numbers and Profitability due to CV of Fertiliser Application

		CV		
	Base	40%	50%	60%
Breeding Ewes	1,933	1,894	1,875	1,856
Breeding Cows	131	130	128	126
Reduction in Breeding Ewes		2%	3%	4%
Reduction in Breeding Cows		1%	2%	4%
Economic Farm Surplus	$141,451	$132,167	$127,575	$124,092
EFS/ha	$277	$259	$250	$243
Change (reduction) in EFS/ha		$18	$27	$34

This indicates that CVs above 40% start to have an increasing impact on farm profitability[3].

Dairy Model

For the dairy model, CV's less than 50% had minimal/zero impact on the model.

Table 5: Impact on Cow Numbers and Milk Production due to CV of Fertiliser Application

		CV	
	Base	50%	60%
Cows Wintered	367	367	367
Milksolid production (kg)	139,523	139,215	137,626
Economic Farm Surplus	$310,864	$309,137	$300,231
EFS/ha	$2,527	$2,513	$2,441
Change (reduction) in EFS/ha		$14	$86

Conclusion

Subject to the assumptions made in this analysis, for a representative North Island hill country sheep & beef farm, increasing CV's above 40% have an impact on dry matter production and subsequently on farm profitability.

Similarly, for the representative Waikato/BoP dairy farm, increasing CV's above 50% have an impact on dry matter production and subsequently on farm profitability.

While the impact of the increasing CV is not necessarily large at a total DM grown level, it is the effect within the year that impacts most; with the tightest feed supply around September/October (for the Hill Country Model) and October – December (for the Dairy Model), any reduction in growth during this period can have a significant impact overall.

[3] It is also worth noting that the cost of spreading well is small compared to the cost incurred of poor distribution in the field.

There is also an inference that increasing CV's have a larger impact at lower fertility levels (or conversely a lower impact at higher fertility levels).

This is illustrated by two factors;

(i) The percentage impacts were greater at the lower Olsen P level, comparing Table 2 percentage figures with Table 3 percentage figures. Albeit this is confused to a degree given the different quantity of pasture grown under the 2 different systems, and

(ii) The impact under the higher fertility dairy farm (Olsen P =25) only started once the CV had reached 50%, whereas it started to impact on the lower fertility sheep & beef farm (Olsen P=10) at a CV of 40%.

Additional Comment

In another paper; *Effects Of Variability In Fertiliser Application On Hill Country Pasture Productivity* (Gillingham et al, FLRC 2005) pasture growth was modelled with 3 different fertility levels, where the targeted track spacing (by the topdressing plane) was varied by 33 and 66%, and fertiliser flow rate from the hopper was varied by 50%.

This showed;

(i) Base pasture growth varied significantly between the low/medium/high fertility areas

(ii) There was no difference in pasture growth within each fertility level as a result of varying the track spacing and flow rates.

The above relates to topdressing with superphosphate. The paper also notes that with respect to nitrogen, given a relatively linear response rate, then a large CV would not make any real difference in overall DM grown. [eg; if applying 30kgN/ha, at 10kgDM/kg N – if apply 30kg/ha evenly, response = 300kgDM. If ½ the paddock gets 15kgN/ha, & the other ½ 45kgN/ha, overall response = 300kgDM/ha].

This would indicate that if the CV of fertiliser application is consistently poor, which is a base assumption underlying the analysis within this paper, then provided the area is of similar fertility for nutrient response, it can be readily mitigated by varying the track spacing of the topdressing machine.

Appendix One: Model Parameters

North Island Hill Country Sheep & Beef Model

Effective Area (ha): Total	511
Steep	227
Rolling	232
Flat	52
Stock Wintered	
Breeding Ewes	1,933
Ewe Hoggets	517
Rams	19
Breeding Cows	131
R 2 Heifers	33
R 1 heifers	71
R 2 Steers	70
R 1 Steers	71
Bulls	3
Lambing % (weaned)	125
Calving % (weaned)	88
Sheep SU	2,503
Cattle SU	1,720
SU/ha	8.3
Lamb slaughter weight (kg)	17.5
R 2 Steer slaughter weight (kg)	300

Waikato/Bay of Plenty Dairy Model

Effective Area (ha): Total	123
Effluent Area	82
Rest of Farm	41
Stock Wintered	
Milking Cows	357
R 1 Heifers	79
Milksolids Production (kg)	139,215

Appendix Two: Model Pasture Production

Hill Country Model

Base	kgDM/ha/day		
	Steep	Rolling	Flat
July	6.7	10.9	15.7
August	8.3	13.6	19.5
September	13.8	22.7	32.5
October	20.4	33.6	48.2
November	26.0	42.7	61.2
December	21.6	35.4	50.8
January	17.2	28.2	40.4
February	9.4	15.4	22.1
March	7.7	12.7	18.2
April	8.8	14.5	20.8
May	7.2	11.8	17.0
June	5.5	9.1	13.0
Annual Total	4,644	7,629	10,947
Weighted Av	6,643		

kgDM/ha/day	50% CV			60% CV		
	Steep	Rolling	Flat	Steep	Rolling	Flat
July	6.5	10.7	15.4	6.4	10.5	15.0
August	8.1	13.3	19.1	7.9	13.0	18.7
September	13.5	22.3	31.9	13.2	21.7	31.1
October	20.1	33.0	47.3	19.6	32.2	46.2
November	25.5	41.9	60.1	24.9	40.9	58.7
December	21.2	34.8	49.9	20.7	33.9	48.7
January	16.8	27.7	39.7	16.4	27.0	38.7
February	9.2	15.1	21.7	9.0	14.8	21.2
March	7.6	12.4	17.8	7.4	12.1	17.4
April	8.7	14.2	20.4	8.5	13.9	19.9
May	7.1	11.6	16.7	6.9	11.4	16.3
June	5.4	8.9	12.8	5.3	8.7	12.5
Annual Total	4,562	7,495	10,754	4,450	7,311	10,490
Weighted Av	6,526			6,366		

Dairy Model

kgDM/ha/day		CV	
	Base	50%	60%
July	21.1	20.9	20.7
August	16.0	15.9	15.7
September	21.1	20.9	20.7
October	48.1	47.7	47.1
November	54.8	54.3	53.6
December	62.4	61.8	61.1
January	55.7	55.2	54.5
February	41.3	40.9	40.4
March	24.5	24.3	24.0
April	27.0	26.8	26.4
May	28.7	28.4	28.1
June	25.3	25.1	24.8
Annual Total	12,954	12,837	12,678