

MASS BALANCE BUDGETS FOR CROPPING SYSTEMS – THEIR ROLE IN NUTRIENT MANAGEMENT

Mathers Diana

*C/O Plant and Food Research, PB 1401, Havelock North 4157
diana.mathers@far.org.nz*

Abstract

Overseer has become the model of choice for most regional councils to assist their understanding of nutrient losses at farm-scale. The farm Overseer nutrient budget numbers for nitrogen and phosphorus are used to gauge the farm's environmental performance with catchment limits.

Arable and vegetable cropping farmers continue to face a number of challenges when having Overseer budgets prepared for their farm systems. These relate to the dynamic and complex nature of many cropping farms, as the complexity of the system increases, the ability to model it decreases and confidence in the output reports may be low. Farmers and regional council land managers have asked if there is an alternative approach to an Overseer nutrient budget or arable systems.

In this work, we explore the concept of using a pre-season, crop mass-balance budget as a nutrient management tool as a substitute for a retrospective Overseer nutrient budget

Historical data sets for maize and potatoes which included nitrogen budgets prepared from pre-season and post-harvest nitrogen soil tests, fertiliser rates and crop yield responses were used to compare mass-balance budgets and Overseer nutrient budgets.

The uncertainties involved in developing a mass balance budget include; estimating the soil nitrogen supply, the fertiliser efficiency and the crop yield. If these uncertainties can be reduced, then a mass balance budget for a crop will provide a level of confidence that fertiliser applications are being applied to meet the crop demand with a minimal surplus.

In long term crop rotations certainty that losses were being controlled and minimised could be achieved if the cropping rotation was managed with the consistent use of mass balance budgets for all the crops, including the pasture and forage crops in the rotation. But without a measure of how well the system is performing, neither the Regional Council nor the farmer can gauge the success of the farm fertiliser management practices.

Background

The National Policy Statement (NPS) for Freshwater Management directs regional councils to consider specific matters about fresh water, both the quantity and its quality, when developing their regional plans and rules for water management.

The implementation of this NPS through new regional council rules is having a considerable impact on farm businesses as farmers are being asked to be accountable for nutrient losses

from their land. To achieve this they must be made aware of the levels of nutrient loss from their farms and understand how and why these losses come about.

It is not possible to directly measure nutrient losses at a farm level so they must be estimated by modelling information relating to the climatic and physical properties of the farm and the associated farm system and its management.

The Overseer Nutrient Budget model is a farm-level, decision support system originally developed for the pastoral sectors. Its primary original use was as a tool for the fertiliser industry to develop fertiliser recommendations for pastoral farmers. The model algorithms calculate mass balance budgets for the pastoral crops using information relating to the farm physical characteristics and production system. As well as maintenance application rates for the key nutrients, the model generates a retrospective nutrient budget for the whole farm and on an individual block basis. This provides an additional benefit for farmers and agronomists in the identification of parts of the farm system where nutrient losses are high.

Because of its ability to model nutrient losses from farm systems, Overseer has become the model of choice for most regional councils to assist their understanding of nutrient losses at farm-scale. The nitrogen loss to water number provides a quick reference point on environmental risk, which summarises complex information about an individual farm system.

Although the Overseer arable and horticultural model was released late in 2011, arable and vegetable cropping farmers continue to face a number of challenges when having Overseer budgets prepared for their farm systems. These relate to the dynamic and complex nature of many cropping farms, involving many crops, and a variety of different animal enterprises which move around the farm grazing on both crop and pasture blocks. As systems become more complex they become more difficult and time consuming to model and confidence in the output reports may be low. For this reason Overseer is probably not the tool of choice for agronomists developing fertiliser recommendations for individual crops. Farmers and regional council land managers have asked if there is an alternative approach.

This paper explores the concept of using a pre-season, crop mass-balance budget as a nutrient management tool as a substitute for a retrospective Overseer nutrient budget

We ask the question:

Can a mass-balance nutrient budget provide the confidence that regional councils are seeking to show that nutrient losses are being controlled in cropping systems?

The mass balance budget is the planning tool for nutrient management for cropping farmers and considered to be good management practice for crop production. Budgets are prepared by farmers and agronomists at the start of the season to calculate the amount of fertiliser that the crop needs to reach a maximum yield.

A nutrient budget can never be as accurate as a financial budget because the nutrient supply to the crop is driven by things that are difficult to predict; these include the size and timing of the nutrient supply from the soil, the weather conditions during the life of the crop, the efficiency of the applied fertiliser and the crop nutrient uptake in response to its growing conditions.

A nutrient budget includes:

1. An assessment of the nutrient status of the soil through soil testing. Soil tests are a key

Nitrogen in particular, can be challenging to estimate because of the fluidity of the nitrogen cycle which depends on the characteristics of the soil environment. Denitrification drives gaseous losses to the air and drainage drives nitrate losses to groundwater. However, the nutrient supply from soils which have been repeatedly cropped with minimal periods of animal grazing is stable and the approach of many farmers is to supply sufficient nutrients to deliver the expected crop yield.

2. The likely yield for the crop which determines nitrogen uptake. This is best estimated from the long term average yield that has been achieved for the paddock and the crop.

Other things to be considered when a budget is being prepared are those factors that may constrain yield such as:

- i. The long-term weather forecast; will it be a wet or a dry season and
- ii. The availability of water,
- iii. Physical soil constraints such as compaction.
- iv. Soil chemistry constraints such as pH.

Approach

Data sets from the calibration studies for the decision support tool, AmaizeN^{1&2} were used to explore the concept of a mass-balance budget for a maize crop.

Data collected for this work included; Mineral N tests collected before planting and after the crop was harvested from soil cores taken in 30 cm increments down to 1.2m, AMN tests and crop yield responses to a range of fertiliser treatments.

A range of fertiliser treatments were applied, including low and high rates and a rate developed by the decision support tools AmaizeN.

The soil test information from these trials was used to prepare a pre-season, mass-balance nitrogen budget for the crop in a way similar to that would be followed by a farmer or agronomist. Two efficiency levels for the supply of nitrogen from the fertiliser were used 50% and 80% efficiency.

Overseer scenarios for a maize silage crop rotation with were developed to test whether the fertiliser recommendations developed by the mass-balance approach are providing a good outcome with respect to nutrient losses from the system. The modelled two year rotation was; two maize silage crops planted in October and harvested in March, with a winter annual ryegrass crop planted in April and grazed by sheep. The rotation began in July. Fertiliser applications for the maize were the experimental treatment rates and the 50% rate recommended in the mass balance budget.

Results

The mass balance fertiliser recommendation assuming a 50% efficiency was:

MAP (11:52:0) applied at planting	190 kg/ha	supplying 21 Kg N/ha
Urea applied at side dressing	411 kg/ha	supplying 189 Kg N/ha

The fertiliser recommendation assuming an 80% efficiency was:

MAP (11:52:0) applied at planting	190 kg/ha	supplying 21 Kg N/ha
Urea applied at side dressing	335 kg/ha	supplying 154 Kg N/ha

A summary of the experimental information and the results are presented in Table 1

Table 1

Summary of the historical experimental data, mass-balance data and the Overseer scenarios

Pre-planting N Soil supply, Kg N/ha		Fertiliser treatment	Silage yield Note No significant yield difference between treatments	N supply at start of season Soil N + Fert N	N removed by the crop	Nitrogen Balance N supply minus N removed	Soil Mineral N after harvest	AmaizeN predicted leaching from a depth of 1.5m.
		Kg N/ha	TDM/ha	Kg N/ha	Kg N/ha	Kg N/ha	Kg N/ha	Kg N/ha
AMN test (potential supply)	65							
Mineral N at planting to 120cm	70	Low rate N=122kg	26.2	257	288	-31.2	108	1.5
Estimated Soil supply	135	Amaize N=242kg	27	377	297	80	219	1.5
		Farmer Practice N=159kg	27	294	297	-3	138	1.5
		High rate N=361kg	24.6	496	271	225	265	1.5
Mass Balance Nitrogen Budget for maize silage – using a planned silage yield of 25T/ha and an estimated soil N supply of 135 KgN/ha								
Estimated Soil supply Kg N/ha	Planned silage yield T/ha	Calculated Nitrogen uptake for the crop Kg/h	Shortfall in supply	Nitrogen to be supplied from fertiliser Kg/ha (assumes a 50% efficiency)	Nitrogen to be supplied from fertiliser Kg/ha (assumes a 80% efficiency)			
135	25	275	140	210	175			
Overseer Modelling								
Nitrogen rates applied as fertiliser to the maize crop for the Overseer modelling								
Low Rate (N=122kg)		Amaize N Rate (N=242kg)	Farmer Rate (N=159kg)	High Rate (N=361kg)	Nutrient Budget (N=210kg)			
Overseer N Loss to Water	5	5	5	9	5			

Discussion

The fertiliser recommendation from the mass balance budget using the AMN and mineral N soil test information was close to the AmaizeN recommendation. In the AmaizeN calibration trials, the application of 242 additional kg of N to the crop, resulted in a silage tonnage of 27 T/ha. A mass balance calculation for N for a planned yield of 27 T/ha, would have been 243 kg of N.

This is a good result. It affirms the value of decision support tools such as mass balance budgets for developing fertiliser recommendations. Farmers and regional councils can be confident that these nutrient management tools are robust, enabling fertiliser recommendations to be developed to deliver planned crop yields with environmental responsibility.

In the maize scenario of continuous cropping with no long term pasture phases the Overseer estimates for nitrogen losses to water are low.

A one-off use of a mass balance budget provides no certainty that N losses are being managed in the long term. However, nitrogen demand information is available for many arable and vegetable crops, enabling mass balance budgets to be constructed throughout a mixed rotation, irrespective of crop, as long as information is also collected about the soil N supply. If this is done consistently, the risk of nitrate moving below the root zone with subsequent leaching losses will be minimised. The down-side is that this nutrient budget gives N no leaching loss estimate for environmental reporting.

And so: Could a mass-balance nutrient budget provide the confidence to the regional councils that nutrient losses are being controlled in cropping systems? Yes it could, but we would need a big turn-around in our thinking.

A mass balance approach is an input management system, but unlike systems where inputs are constrained for environmental management, nutrient recommendations can enable any level of planned yield in any crop. This is out of line with the output management system which is our current and preferred approach to environmental reporting and the focus of the many regional council plan changes being developed around the country. In this current environment farmers will have little choice and they will need to report on their nutrient outputs via Overseer nutrient budgets. However they can have confidence that by using mass-balance budgets they are following the agreed good management practice which will offer savings on fertiliser costs without restricting their crop production.

References

AmaizeN – Nitrogen management for sustainable maize production

October 2008

P Johnstone, F Li, A Fletcher, P Jamieson & N Arnold. *New Zealand Institute for Crop and Food Research Limited, 265 Lawn Road, RD2, Hastings, New Zealand.*

Another AmaizeN Year:

Report on SFF project 05/096 'Nitrogen management for sustainable maize production'

July 2007

F Y Li, P D Jamieson, P R Johnstone, H E Brown, A J Pearson & R F Zyskowski
New Zealand Institute for Crop & Food Research Limited, Private Bag 4704, Christchurch, New Zealand