BEFORE THE HEARING COMMISSIONERS

IN THE MATTER	of the Resource Management Act 1991 ("**the Act**")
AND	
IN THE MATTER	of the Resource Management Act 1991 and the Environment Canterbury (Temporary Commissioners and Improved Water Management) Act 2010

STATEMENT OF REBUTTAL EVIDENCE BY CHRISTOPHER MARTIN KEENAN FOR HORTICULTURE NEW ZEALAND

9 SEPTEMBER 2014

ATKINS | HOLM | MAJUREY

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QUALIFICATIONS AND EXPERIENCE

1. My full name is Christopher Martin Keenan, my qualifications and experience are set out in my evidence in chief.

CONTEXT AND SCOPE OF MY REBUTTAL EVIDENCE

2. The context and scope of my rebuttal evidence is to respond to the statements of evidence from:

   a. Gerard Willis;

   b. S Pearson;

   c. Alison Dewes;

   d. Lionel Hume;

   e. Stephen Douglass;

   f. Robert Potts;

   g. M Keaney;

   h. Andrew Curtis;

   i. Tim Ensor;

   j. Anthony Davoren;

   k. Geoffrey Deavoll;

   l. Ian McIndoe; and

   m. Jim Cooke.

3. A summary of my rebuttal evidence is:

   a. Given the alternative approaches requested for clawback of nutrients by Willis, Pearson and Hume, I submit my preferred alternative to the notified approach in proposed policy 11.4.14.

   b. A discussion on the evidence regarding transfers and reliability.

   c. Use and frequency of nutrient budgets prepared by experts.

   d. Accounting frameworks and the relevance of SOURCE modelling.

e. Whether or not Variation 1 reflects a single nutrient approach.

APPROACHES TO MANAGING NITROGEN DISCHARGE ALLOWANCE

4. Willis[1], Pearson[2] and Hume[3] all seek different regimes for phasing out overallocation. Their responses include shorter timeframes to achieve objectives. They seek different objectives and some maintain that different parties are responsible for a greater or lesser proportion of the costs to phase out overallocation.

5. Alison Dewes introduces the concept of "equity in pollution rights"[4]. The difficulty is in defining what "equity" is in this context. In my view, the principles for nutrient allocation[5] attached to my Evidence in Chief describe the conditions where equity might be found.

6. In my view a system that grandparents some discharges in transition, followed by a move to an equal allocation of nutrients across similar production land after a period of time provides the most equity. In the short term, it recognises the legitimate expectations of individuals to depreciate out their invested capital, and in the long term it ensures that similar production land has a similar entitlement to encourage flexibility.

7. I agree with Dewes[6] that 2022 would be a suitable date for all farmers to achieve a minimum of Good Management Practice as defined by the MGM process This would include the systems developed to audit farm plans and the trained independent certifiers to ensure GMP is managing the risks associated with different farm systems.

8. It is my view that by 2022 the Regional Authority and the primary sector will have developed the on farm accountant and the catchment accountant to a point where a transfer system would be feasible to operate, to move nutrients to the

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[1] EIC G Willis para 111

[2] EIC Pearson Appendix 5

[3] EIC Hume paras 29 - 30

[4] Dewes EIC Para 122.

[5] http://www.hortnz.co.nz/users/Image/Downloads/PDFs/hortnz-nutrient-allocation-principles-final.doc

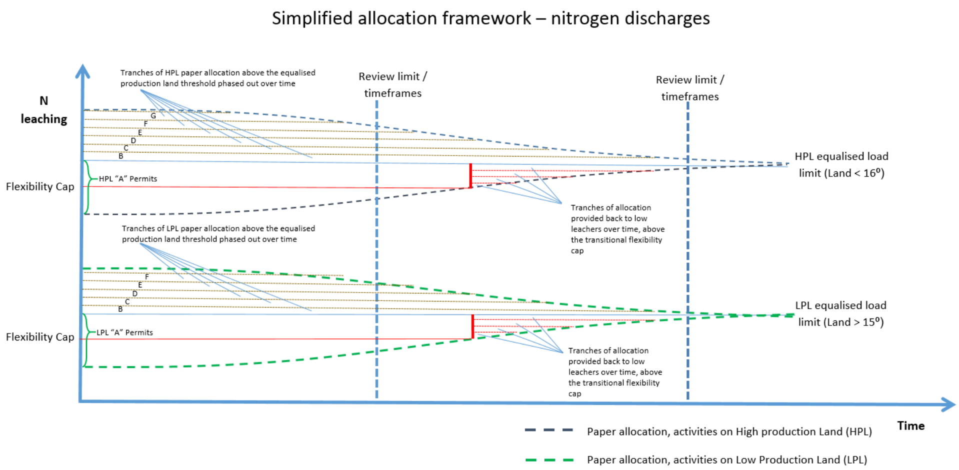
[6] Dewes EIC para 179.

highest value uses within a catchment limit. In my view that would be required to encourage flexibility of land use to the greatest extent possible.

9. With a transfer system in place, a transitional grandparenting approach can be phased out over time. In my view, the imposed "flexibility cap" could also be phased out, potentially by 2028. Phasing out of overallocation should not necessarily require low leaching land use activities to absorb the effects of higher discharges in perpetuity.

10. I propose the Variation outlines a set of numeric values for discharge allowances to be equalised over time; with tranches of nutrient discharge allowance phased out progressively for high emitters, and tranches of allocation to be phased in for low emitters over time.

11. **Figure 1** below outlines my preferred approach (note a larger version of this figure is attached at the end of this statement of rebuttal evidence):



12. In Figure 1 above, I would propose that the start date for the issuance of discharge allowances would begin in 2022. Regular reviews would be required to ensure the on farm accountants and catchment accountants could be updated. The reviews would also allow for ongoing assessment of the economic consequences, allowing for an adaptive management approach to achieving the limits.

13. Land could be divided simply into land with a slope greater than 15 degrees or less than 15 degrees. The basis for this division is that land less than 15 degrees is more accessible with tractors / cultivation equipment / and or irrigation equipment. I have checked with the SKM / Jacobs team providing science

support for primary submissions and they note[7] that production land divides in this way as follows:

a. Area greater than 15 degrees: **151 ha;**

b. Area less than 15 degrees: **183,968 ha.**

14. I would propose that land below 15 degrees could be allocated at a ratio of 2 units to every 1 unit of allowance for land greater than 15 degrees. If I base my calculations on these proportions an equalised load limit would be roughly **22kg/N/ha/yr** on land less than 15 degrees, and **11kg/N/ha/yr** on land greater than 15 degrees in slope.

15. The equalised load limits per hectare would be reached at the end of the transition period. Activities that leach higher than the allowed discharge limit would have the following options to comply:

a. Obtain a transfer of nitrogen allowance from land that is not utilising the full allowance;

b. Provide offsite mitigation that reduces total nitrogen discharge to the affected waterbodies;

c. Improve their capital investment in technology to reduce outputs / discharges;

d. Operate as a group of farmers akin to an irrigation scheme, to share a proportion of the load for greater flexibility;

e. Change the system to reduce discharges.

16. I would propose that the tranches of allocation phased out initially would be those of higher leaching activities. With reference to figure 1 provided above, the "G"[8] tranche would expire first, followed by the other tranches in descending order. Table 1 below provides a schedule of suggested dates. I have concentrated on populating the HPL figures given the LPL proportions of land are very low:

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[7] See **Attachment 1** to this rebuttal - email from Thomas Nation (Jacobs SKM) outlining land figures. Please note: the land figures do not match up to Table 2 land proportions because non production land (mostly lifestyle blocks) have been removed from the totals. The per hectare discharge allowance would change should lifestyle blocks be excluded from the discharge allowance regime.

[8] The Figure is just illustrative – In the Table I have provided tranches up to "I" to fit the proposed timeframe although some other range may be appropriate.

Table 1 - proposed rates of reduction

Descriptor	Allocated leaching rate (kg/N/ha/yr)	Proposed date of expiry / granting
Flexibility Cap HPL	15	2028
Tranche 1 reductions for high emitters (I)	Between current and 82	2026
Tranche 2 reductions for high emitters (H)	82 - 75	2030
Tranche 3 reductions for high emitters (G)	75 - 65	2035
Tranche 4 reductions for high emitters (F)	65 - 55	2040
Tranche 5 reductions for high emitters (E)	55 - 45	2045
Tranche 3 reductions for high emitters (D)	45 - 35	2050
Tranche 3 reductions for high emitters (C)	35 - 25	2055
Tranche 3 reductions for high emitters (B)	25 - 22	2060
HPL low leaching entitlement returned Tranche 1	15 - 17	2028
HPL low leaching entitlement returned Tranche 2	17 – 19	2030
HPL low leaching entitlement returned Tranche 3	19 - 21	2032
HPL low leaching entitlement returned Tranche 4	21 - 22	2034

17. One criticism of this approach may be that low levels of discharge attract less cost as a result of this framework. However I consider that the low emitters may be less of the overallocation issue so this is appropriate. There will be costs imposed with undertaking farm planning, audit and moving to good management practice in many cases. It is also likely that land valuation effects impact on capital values for low leachers, due to the reduced flexibility for land use activity change.

18. I disagree with the approach adopted by Gerard Willis[9] because his "equalised approach" to reductions does not account for the fact that there is not an equalised approach in respect to the discharge allowances of differing activities. Nor does he clarify who will bear the costs of his approach succinctly enough in my view to guide implementation of the plan.

19. I disagree with the approach adopted by Dr Hume, because it provides a greater allowance to land that leaches more in

[9] EIC G Willis para 111

perpetuity. In my view that would reward activities with higher discharges, and this would appear to run against the "polluter pays" principle.

20. I disagree with the approach presented by Pearson, Deavoll and Dewes because they seek an uncosted series of reduction targets, and there is no economic rationale to support them.

21. I disagree with the approach of Potts[10] and Douglass[11] because they infer non-point source discharge allowances from consented point source – type activities and seek preferential rates of leaching that are higher than the proposed non – complying activity threshold for production land. In my view it would be preferable to deal with these industrial discharges as point source activities.

COMMISSIONING OF NUTRIENT BUDGETS

22. Mr Keaney seeks that nutrient budgets are produced every year using Overseer. He also seeks that the nutrient budget is provided by someone who has completed the Overseer – related nutrient budget courses from Massey.

23. I have provided as **Attachment 2** an email containing a word document from Mr Roger Lasham, an agronomist for Turley Farms. His email and attached document quite clearly demonstrate some of the issues with undertaking this approach on cropping farms.

24. I have also discussed the Overseer courses from Massey (with respect to cropping) with many growers. No growers have indicated to me that the courses equip someone to provide nutrient budgeting advice to a cropping farmer. Growers are far more likely to seek the advice of an experienced agronomist, who understands the unique nature of rotational cropping.

25. The cropping systems are in my view not similar at all to pastoral systems. The vast majority of certified nutrient management advisors specialise in pastoral systems, so the courses provide no guarantee that a certified nutrient management advisor is fit for the purpose of designing a nutrient budget for a cropping farm.

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[10] EIC Potts para 64

[11] EIC Douglass para 35

26. In Horizons, this has been demonstrated in implementing the One Plan. Horticulture NZ has had to train two independent consultants in use of a Code of Practice to assess leaching risk based on adherence to recognised practices.

27. In the future we hope to reorganise the Massey Nutrient Advisor courses to incorporate the material we have been developing, to provide better certification for qualified professionals, but this has not been done.

28. I have attached (**Attachment 3**) the readings for the advanced course in nutrient management at Massey regarding nutrient leaching. You will note that the most recent literature is 2003. In my assessment the material is very out of date given the advances in understanding that have occurred in the last ten years.

RELIABILITY OF SUPPLY AND TRANSFER

29. Geoffrey Deavoll[12] supports the lowered reliability (8.5 years out of ten as opposed to 9) but does not indicate he has done any assessment of what the results of lower reliability would be. Andrew Curtis[13] points out how this would significantly influence the presence of horticultural opportunity. Lower reliability would be more supportive of pastoral land use in my view.

30. I consider this would decrease the resilience of the rural sector because there would be less options for horticultural land use activities. Given that one of the key objectives for the plan change appears to be managing excess nitrogen discharges (and that low leaching fruit production may support this, but would require higher reliability).

31. Curtis[14] also provides a good outline of why transfer should be encouraged, particularly short term transfer. Given the need for high reliability water users often have excess water. To increase the availability of this water for other users in times of need would improve allocative efficiency.

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[12] EIC Paras 29 - 38

[13] EIC Andrew Curtis para 23

[14] EIC Andrew Curtis Paras 12 - 20

32. So I agree with the views of A Davoren[15] and Tim Ensor[16] regarding the inappropriateness of the proposed clawback of 50% for any transferred water.

ACCOUNTING FRAMEWORKS

33. Dr Jim Cooke[17] notes that an accounting framework will be necessary to manage within limits on an ongoing basis, and the need for models to account for attenuation appropriately. I agree with his assessment of the importance of accounting frameworks.

34. I consider that the SOURCE modelling produced by the SKM / Jacobs team could provide the basis for the catchment scale accountant, given that it meets the criteria Dr Cooke lays out[18].

SINGLE / DUAL NUTRIENT APPROACHES

35. I do not consider that Variation 1 is taking a "single nutrient" approach to managing water quality. Dewes[19] suggests there is not enough evidence on management of phosphorous.

36. Phosphorous controls in the plan are both regulatory and non-regulatory. They are often mixed with controls for soil conservation.

37. I agree there is no modelled phosphorous load and the accounting framework is less developed than it is regarding nitrogen. I have attached as evidence reports written by Stuart Ford that outline some of the challenges using Overseer to estimate phosphorous leaching.

38. In addition, I have attached to my evidence in chief our code of practice for minimising erosion from cultivated land. The Code does not mandate a range of practices, rather it provides a risk assessment framework and a range of tools, to allow growers to make practical and effective decisions given differing circumstances.

39. The farm plan is probably the most effective place to incorporate management techniques to manage phosphorous

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[15] EIC Davoren for Hydrotrader paras 24 - 28

[16] EIC Ensor for Winstone Aggregates paras 24 - 33

[17] EIC Jim Cooke paras 56 – 58

[18] EIC Cooke para 55

[19] EIC Dewes para 69

and sediment. I do not consider it is necessary to undertake changes to the plan to better manage phosphorous given the combination of regulatory and non-regulatory controls aimed at managing this.

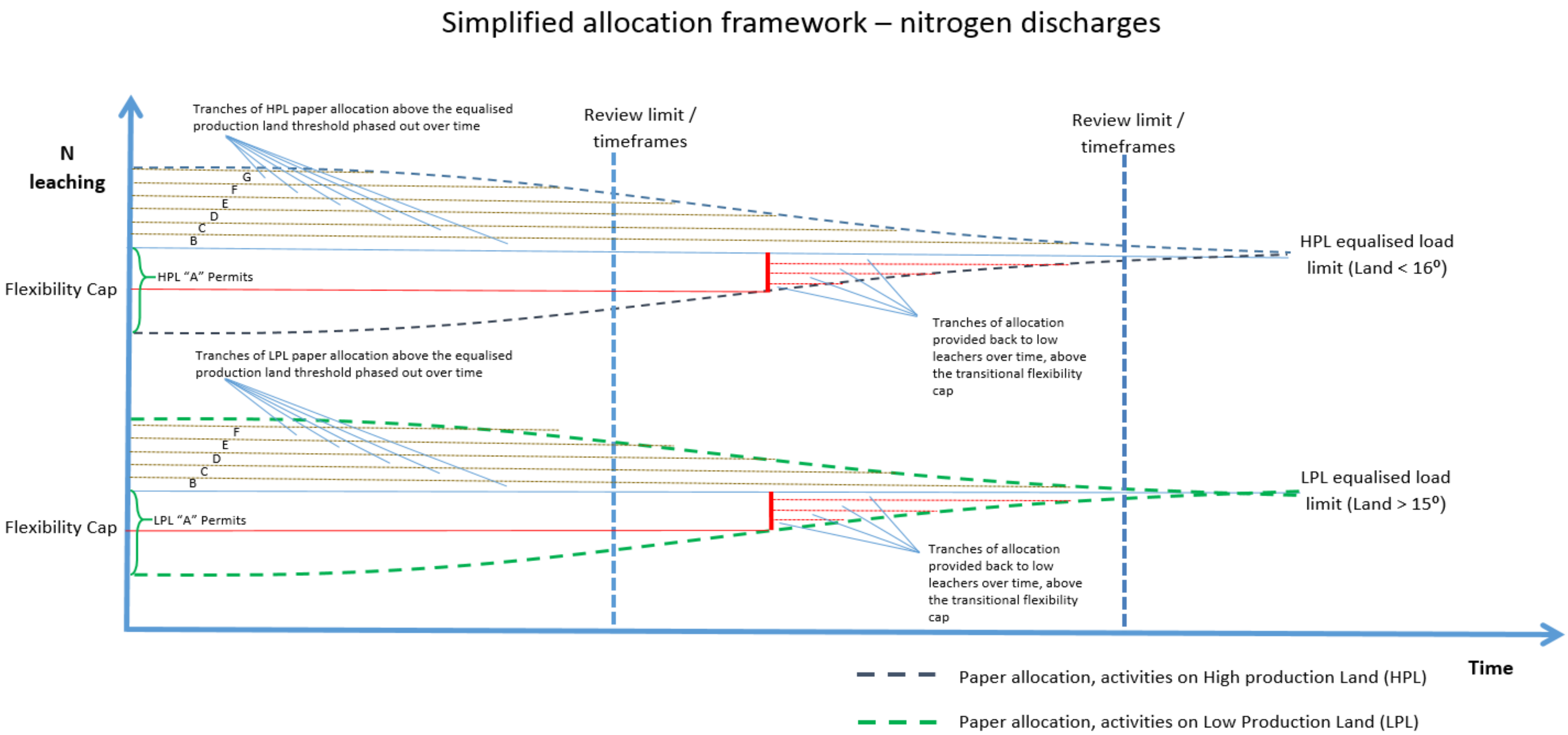
CONCLUSIONS

40. For all the reasons outlined in this statement of rebuttal evidence nothing I have given in evidence in chief has changed as a result of my review of the various statements of evidence outlined above.

Christopher Martin Keenan

9 September 2014

TABLE 1 (SEE PARAGRAPH 11)



From: Nation, Thomas [TNation@globalskm.com]
Sent: Monday, 8 September 2014 10:26 a.m.
To: Chris Keenan
Cc: Conland, Nic
Subject: RE: Query

Hi Chris,

Below are the slope statistics you inquired about. I removed non-productive landuse from the catchment layer (i.e. town, forestry, lifestyle) and calculated the area that is greater than 15 degrees in slope and that area that is less than 15 degrees.

Area greater than 15 degrees: **150 ha**
Area less than 15 degrees: **183,968 ha**

Let me know if you need clarification or changes

Tom Nation | Jacobs | Spatial Analyst | +64 4 914 8412 | thomas.nation@jacobs.com | www.jacobs.com

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From: Conland, Nic
Sent: Monday, 8 September 2014 9:02 AM
To: Nation, Thomas
Subject: FW: Query

Tom,

Can you please have a look at this and give Chris an answer

Kind Regards

Nic Conland
Jacobs
Senior Environmental Consultant | ANZ Infrastructure and Environment
+64 4 914 8419 86 Customhouse Quay
+64 274 135 699 Wellington 6011
Nic.Conland@jacobs.com New Zealand

From: Chris Keenan [mailto:Chris.Keenan@hortnz.co.nz]
Sent: Monday, 8 September 2014 8:42 AM
To: Conland, Nic
Cc: vance@hpcplanning.co.nz; Angela Halliday
Subject: Query

Hi Nic, I'm assuming it is relatively easy for you to give us the number of production land hectares in the Selwyn Waihora catchment either over 15degrees slope class or under? We'd appreciate if we could have this number in time to enter our rebuttal evidence today?

Kind regards and thanks

Chris Keenan
Manager, Natural Resources and Environment
Horticulture New Zealand | Our Growth Industry
ddi + 64 4 470 5669 | fax + 64 4 471 2861| mob 027 668 0142
Level 4, The Co-operative Bank House | 20 Ballance Street | PO Box 10232 | Wellington 6011
New Zealand

Check out Horticulture NZ's new codes of practice for sustainable vegetable production, here, here, and check out information on vegetable production financial performance here

From:	Roger Lasham [rogerlasham@turleyfarms.co.nz]
Sent:	Tuesday, 29 April 2014 1:39 p.m.
To:	Chris Keenan
Cc:	'Murray Turley'
Subject:	Nutrient budgets
Attachments:	Overseer is this a practical way to do a Nutrient Budget.docx

HI Chris
Further to our conversation
A few notes on what I found when attempting to do a real Nutrient plan.
Roger

Overseer is this a practical way to do a Nutrient Budget ?

Background-

Turley farms Ltd is a Sizable cropping business growing 15 different crops from broad acre Cereal crops to Vegetable production and specialist seed production crops.

Combine this with sheep enterprises lamb fattening and a breeding flock of Ewes, Dairy support and some beef fattening. With this complex business I attempted to enter the farm business into overseer to evaluate the nutrient losses to the environment. Having spent the first afternoon trying to navigate around the computer program and decide on the best way forward I have decided this is going to be hugely onerous on time and resource. My estimate for completing this information to an accurate level with the complexity of our enterprise could be as much a 3 working weeks to complete the farm Nutrient budget.

Breakdown of time and information required.

105 Fields to consider with the complexity of the rotation each field will have to be a separate block as no two fields have the same management practises.

105 Fields x 3 cropping entries =315

105 soil type entries =105

105 weather records = 105

105 beef sheep and dairy grazing's to consider =210

105 cultivations X 3 = 315

Irrigations 105 X 5 on average X2 years = 1050

Fertiliser 105 X 5aplications to record X2 Years =1050

Total number of entries estimated at 3150

We have good farm records and most information is on hand but still this will be quite time consuming. Some records haven't been kept around specifics of where stock have grazed and for how long.

Other issues – several crops we grow are absent from the lists and substitute crops need to be put in to make this work which will lead to poor information coming out in the final report.

To that end I will be waiting for an alternative approach to this task and carry on using best practise until change in policy or farming practise make this a requirement.

Roger Lasham 29/4/14

Reading 3.2.1

Williams, P.H., and Tregurtha, C.S. 2003. Managing nitrogen during winter in organic and conventional vegetable cropping systems. *Agronomy New Zealand, 32*: 61-67.

Managing nitrogen during winter in organic and conventional vegetable cropping systems

P.H. Williams and C.S. Tregurtha

New Zealand Institute for Crop & Food Research Ltd,
Private Bag 4704, Christchurch

Abstract

Intensive vegetable crop rotations require inputs of nitrogen (N) to maintain high levels of production and crop quality. Managing N over the winter period is often the most difficult as plant growth is slow and the potential for nitrate leaching is high. Comparisons of N inputs and outputs in a range of winter crops showed that inputs usually exceeded N outputs. Leaching losses ranged from 11 to 246 kg N/ha. The highest leaching losses occurred when high rates of fertiliser N (300-350 kg N/ha) were applied to the crop at planting when the plants were too small to recover much of the applied N Leaching losses were also greater when the soil mineral N content at the start of the winter was high (e.g. 84 kg mineral N/ha in the 0-60 cm depth of soil compared with 39 kg N/ha). Mineral N contents at the start of winter ranged from 39 to 427 kg N/ha, depending on the previous crop history. The highest value was where compost was regularly used as a soil amendment. There is considerable scope to utilise N more efficiently in winter vegetable production systems by matching N inputs to crop demand and adjusting N inputs to allow for the amount of mineral N present in the soil at planting time.

Not all land under intensive vegetable production is used to grow crops over winter. Uncropped land may be left fallow or planted in a cover crop over winter. Rapidly growing species like triticale and oats can be sown as cover crops over winter. These crops will take up mineral N from the soil, and thus have the potential to reduce nitrate leaching losses. At the Aorangi trial site in the Manawatu, cover crops produced 14-18 t DM/ha between April and September and reduced nitrate leaching in the fallow plots from 38 kg N/ha to 13-20 kg N/ha. Leguminous crops can also be grown over winter to supply N to subsequent crops. At the Leeston trial site in Canterbury, lupins grown over the winter added 60 kg N/ha to the soil.

Additional key words: nitrogen fertiliser, compost, nitrate leaching, cover crops

Introduction

Intensive vegetable production in New Zealand covers an area of approximately 55 500 ha (Kerr *et al.*, 2002). In areas like Pukekohe, Otaki and Oamaru where soil type and climate are favourable, potatoes, spinach, cabbages, broccoli and other green vegetables are grown all year round. Up to three crops per year can be grown, usually with high levels of N inputs.

The winter period is often the most critical for managing N. Leaching losses can be particularly high during winter due to drainage from excess rainfall combined with high nitrate concentrations in the soil from winter fertiliser applications or left over from crops grown during the preceding summer/autumn. Leaching losses of >200 kg N/ha from winter vegetable crops have been recorded in Pukekohe and Levin (Spiers *et al.*, 1996; Williams *et al.*, 2000a; Francis *et al.*, 2002). Such losses represent both an economic loss of N from the farm and an environmental concern when the leached nitrate contaminates surface and ground water. Intensive vegetable production is thought to be the cause of the high nitrate concentrations (>10 µg nitrate-N/ml) recorded in some wells in Pukekohe (Selvarajah, 1999).

The N inputs are particularly high in winter vegetable crops (e.g. >300 kg N/ha; Wood, 1997) to compensate for perceived slower growth rates and plant N uptake. For conventionally grown crops, these N inputs are usually in the form of soluble N fertiliser. Being soluble, this N has a high risk of being leached over winter if not utilised by the crop. For organic farming systems, biological soil processes rather than soluble fertilisers are relied on to provide a source of mineral N to the crop. Thus, organic sources of N are applied to organic crops (e.g. compost and inclusion of legumes in the crop rotation) and the N is released to the crops via mineralisation. In both systems the challenge is to match the N inputs to crop demand to ensure the

Reading 3.2.2

Martin, R.J., Craighead, M.D., Williams, P.H. and Tregurtha, C.S. 2001. Effect of fertiliser rate and type on the yield and nitrogen balance of a Pukekohe potato crop. *Agronomy New Zealand, 31*: 71-79.

Effect of fertiliser rate and type on the yield and nitrogen balance of a Pukekohe potato crop

R.J. Martin, M.D. Craighead[1,2], P.H. Williams and C.S. Tregurtha

New Zealand Institute for Crop & Food Research Limited, Private Bag 4704, Christchurch
[1] Ravensdown Fertiliser Co-operative Limited, Box 1049, Christchurch
[2] current address: Nutrient Solutions Ltd., 19 Aynsley Terrace, Christchurch

Abstract

The possibility of reducing the financial and environmental costs of fertiliser application to potatoes (*Solanum tuberosum* L.) by reducing the rate of application of nitrogen (N) fertiliser, and by using slow release or foliar fertilisers to make the fertiliser N more slowly available to the crop but without impacting on yield, was investigated. An experiment at Pukekohe in the winter of 2000 examined the effect of rate and form of N fertiliser on the growth, yield and N balance of a potato crop. The fertilisers used were ammonium sulphate nitrate (ASN) at 242, 350 and 472 kg N/ha, ASN coated with the N-release inhibitor dimethylpyrazole phosphate (DMPP) at 242 and 350 kg N/ha, and the foliar fertiliser Supa N 32 (four applications of 4 kg N/ha as Supa N 32 over 336 kg N/ha applied as ASN). There was no significant increase ($P<0.05$) in tuber yield with N applications over 242 kg/ha, and form of N had no significant effect ($P<0.05$) on tuber yield. Petiole nitrate levels in fertilised treatments were generally over 20,000 mg/kg, excessive according to USA guidelines, so N was not limiting yield. N leaching losses were 82 kg/ha without any N fertiliser application. Leaching under ASN was 167 to 208 kg N/ha. Increasing the ASN rate over 242 kg N/ha resulted in an accumulation of over 200 kg mineral N/ha as nitrate in the soil profile when the crop was harvested. Coating with an N inhibitor reduced leaching by around 30%, but also led to an accumulation of over 250 kg mineral N/ha as ammonium in the soil profile when the crop was harvested. Applying some fertiliser as a foliar spray had no significant effect on leaching or mineral N accumulation. A green manure oat crop, planted after the potato crop was harvested in October, was sampled for yield and N content in January 2001. The oat crop took up 52 kg N/ha in the control plots, and 87 to 133 kg N/ha from the N fertiliser plots, with significantly more being taken up by the ex DMPP plots at equivalent fertiliser rates. This entire N was mulched back into the soil as organic N.

Additional key words: *nitrogen inhibitor, foliar fertiliser, slow release fertiliser, leaching, oats, green manure, petiole nitrate.*

Introduction

Current fertiliser practice for winter grown potatoes in New Zealand is to apply up to 500 kg fertiliser nitrogen (N), on the basis that any deficiency reduces yield. However, research results both in New Zealand (e.g., Martin, 1995b) and overseas (Rourke, 1985) indicate that much of this fertiliser is not taken up by the crop, and could well leach into groundwater either during the growth of the crop or after the crop is harvested. Overseas research has shown that leachable fertiliser levels are higher under potatoes than many other crops (Sylvester-Bradley and Chambers, 1992), and a New Zealand study predicted that winter-grown potato crops in the Pukekohe area are likely to have the greatest impact on groundwater nitrate of any vegetable crop (Crush *et al.*, 1997). Vegetable production has already been identified as a major contributor to the high concentration of nitrate measured in groundwater in the Pukekohe area (Selvarajah, 1999). Regional councils are becoming increasingly concerned about groundwater quality and may place restrictions on applications of fertiliser at levels they consider excessive. Research and farmer trials overseas indicate

Reading 3.2.3

Francis, G.S., Trimmer, L.A., Tregurtha, C.S., Williams, P.H. and Butler R.C. 2003. Winter nitrate leaching losses from three land uses in the Pukekohe area of New Zealand. *New Zealand Journal of Agricultural Research, 46*: 215-224.

New Zealand Journal of Agricultural Research, 2003, Vol. 46: 215–224 215
0028–8233/03/4603–0215 $7.00/0

Winter nitrate leaching losses from three land uses in the Pukekohe area of New Zealand

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L. A. TRIMMER
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Abstract The effects of three different land uses (dairy grazing, winter potatoes, and winter greens [spinach, cauliflower or cabbage] production) on soil mineral N contents and nitrate leaching losses from late June to early October 2000 were investigated on 18 commercial paddocks. All paddocks were in the Pukekohe area (approximately 50 km south of Auckland) on Patumahoe clay loam soils and received typical management practices for the district. On average, dairy paddocks received the least amount of N fertiliser during the study period (84 kg N ha^{-1}), had the lowest soil mineral N content in June (32 kg N ha^{-1}) and had the lowest leaching loss (15 kg N ha^{-1}). On average, potato paddocks received the greatest amount of N fertiliser (481 kg N ha^{-1}), had the greatest soil mineral N content in June (184 kg N ha^{-1}) and had the greatest leaching loss (114 kg N ha^{-1}). The winter greens paddocks were intermediate between the other land uses. Leaching losses from the potato and greens paddocks were the result of large applications of fertiliser N before winter and the rapid mineralisation of residues from the previous greens crops.

Keywords nitrate leaching; dairying; potato; green vegetables; groundwater; fertiliser

A02046; Online publication date 9 September 2003
Received 24 July 2002; accepted 10 April 2003

INTRODUCTION

Elevated nitrate concentrations have been measured in shallow groundwater and surface water in many areas of New Zealand (Bright et al. 1998; Francis et al. 1999). In most cases, non-point sources in intensive agricultural production systems are regarded as the main contributor to this contamination (Selvarajah et al. 1994; Cathcart 1996). However, the land use that contributes most to this contamination may vary between regions. For example, contamination of groundwater and surface water in New Zealand is perceived to be a serious consequence of dairy farming in some regions (de Klein & Ledgard 2001) and of winter vegetable production in other regions (Anon. 1997; Crush et al. 1997). Similar concerns have been reported overseas for both dairy production (e.g., Jarvis 2000) and vegetable crops (e.g., MacDonald et al. 1997; Waddell et al. 2000).

Leaching losses under dairying arise from high rates of N cycling in grazed pastures, with the size of the potential leaching loss increasing with the stocking rate (Jarvis 2000). Most of the nitrate that is leached from dairy pastures comes from urine patch areas, which have very high concentrations of N that are greatly in excess of immediate plant requirements (Haynes & Williams 1993; Ledgard et al. 1999). In contrast, nitrate that is leached from winter vegetable crops largely originates from either applied N fertiliser or from the breakdown of postharvest crop residues. High rates of N fertiliser are often applied to these crops in an attempt to overcome their slow growth rates and their sparse root systems (Goulding 2000). Yields are often increased by these high fertiliser rates, although fertiliser recovery rates are often low, leaving large amounts of N in the soil that are susceptible to leaching (Greenwood et al. 1989; Rahn et al. 1992). The return of large amounts of postharvest plant residues also contributes to the high leaching loss potential under vegetable cropping. The returned residues usually have low C:N ratios and mineralise rapidly when incorporated, resulting in the

Reading 3.2.4

Greenwood, D.J. 2001. Modeling N-response of field vegetable crops grown under diverse conditions with N-ABLE: a review. *Journal of Plant Nutrition, 24(11)*, 1799-1815.

MODELING N-RESPONSE OF FIELD VEGETABLE CROPS GROWN UNDER DIVERSE CONDITIONS WITH N_ABLE: A REVIEW

Duncan J. Greenwood

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Warwick, UK, CV35 9EF;
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ABSTRACT

The development of advice on the use of nitrogen (N) fertilizers for vegetable crops in the UK is complicated by the numerous crops and the widely different ways in which they are grown. Modeling approaches have been adopted to provide cost effective means of solving the problem. It is based on fundamentally derived equations for groups of processes that dominate plant nutrition. The equations include ones for the decline in critical %N with increase in plant mass, for the dependence of growth rate on sub-optimal %N, and for the development of roots systems and their ability to extract nitrate from soil. They have been combined with those for soil processes into a model, N_ABLE, which calculates daily increments in N-uptake, growth, changes in the distributions of water and nitrate down the soil profile and the amounts of N leached out of the profile. It requires only readily available inputs; it has been calibrated for different crops and its validity tested against the results of

Reading 3.2.5

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Evaluating a crop nitrogen simulation model, N_ABLE, using a field experiment with lettuce

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Abstract

A field experiment with lettuce was carried out to evaluate the simulation model, N_ABLE, which has been widely used to predict soil mineral nitrogen requirements and potential leaching hazards for vegetable and arable crops in England and parts of Western Europe. Plant and soil were sampled regularly and dry weight (*W*), percent N in dry matter and soil mineral N (*soil-N*) were measured. Measured *W* and *soil-N* were compared with data simulated using N_ABLE both during growth and at final harvest. Dry weight followed an asymmetrical S-shaped curve when the growth period was either 57 or 61 days for all N levels. This implies that N_ABLE, which assumes a J-shaped growth curve, can only be used in the first three-quarters of the growing period. Simulated *soil-N* in the 0–30 cm layer corresponded well with measured values throughout the experiment when parameters for the recovery of soil mineral N (*REC*) and mineralisation rate of soil organic-N (*NR*) were set at 0.70 (i.e. 70%) and 0.86 kg ha^{-1} d^{-1} respectively, both calculated from field data, and were higher than default values. For longer periods of growth, the best fit was obtained using a modified asymmetrical S-shaped growth curve equation $dW/dT = k_2 W\, G_f\, G_k /(1+W)$, where k_2 is a growth rate coefficient, G_f (≤ 1) is a correction coefficient to allow for any restriction in growth rate caused by sub-optimal%N in the crop and $G_k = (W_k/W)^n$ is another correction coefficient to adjust the growth rate which is decreased caused by genetic or other reasons in the later part of the growth period. The S-shaped equation was examined by a lack of fit test, and the results showed that the residual errors ($SS_R = \sum(y-x)^2$, where x =simulated values, y = measured values) were not significantly different from experimental error, indicating that the S-shaped equation gave a good description of growth for the different N levels through the growth periods.

Introduction

There are indications that simulation models will be more widely used to analyse complex cropping systems (Jones, 1990), as models provide information which is unobtainable from experimental procedures (Angus et al., 1993; Singh & Thornton, 1992). However, the process of model validation is considered as one of the most perplexing aspects of modelling (O'Leary & Connor, 1996a, b; Welch et al., 1981; Whitmore, 1991). In the last decade, several workshops have been held in the Netherlands to compare the performance of dynamic nitrogen models in crop and soil (De Willigen & Neeteson, 1985; Groot & Verberne, 1991) and for prediction of potato yield using a single data set (Kabat et al., 1995; MacKerron, 1992). Recently, Barnett et al. (1997) compared 3 major wheat models, AFRCWHEAT (UK), CERES (U.S.A) and SIRUS (New Zealand), using a powerful data set from more than 1000 wheat trials in the UK covering an 18-year period from 1975. An even more extensive comparison of five models is given by Jamieson et al. (1998). Many validations have also been made in which an individual model has been tested with different data sets (Addiscott & Whitmore, 1987; Graf et al., 1991).

N_ABLE is a deterministic dynamic nitrogen simulation model designed by Greenwood et al. (1996a)