“Achieving Outcomes by Building Capability”

The AgriBusiness Group™

Hawkes Bay Horticultural Nutrient and Financial Benchmarking Results

Prepared for: Horticulture New Zealand and Hawkes Bay Regional Council
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1 Executive Summary

This survey was commissioned by Horticulture New Zealand (HortNZ) and the Hawkes Bay Regional Council (HBRC). HortNZ wished to understand the absolute values and the ranges of values amongst growers in the Hawkes Bay as to N leaching and the financial performance which was being achieved by growers in the region. HBRC wished to gain values which they could use in their region wide modelling of the losses of N and P.

The survey instrument used was in an Excel format which was filled out by the interviewer during the visit to the grower. It had three sections:

- Questions into the **growing operation** which were sufficient to be able to model the operation in Overseer.
- Questions as to the **management practices** carried out on the farm which was designed to test whether the grower was operating at good or best management practice.
- The **financial performance** of the operation which detailed the financial performance of each individual variety or crop.

In total there were twenty eight surveys carried out so the number interviewed were a representative sample rather than a highly significant statistical sample. Half of these were carried out by AgFirst who interviewed the orchard growers and half were carried out by The AgriBusiness Group who interviewed the vegetable growers.

We believe that considerable caution should be used in the use of nutrient benchmarking results produced in Overseer for the Horticultural industry. The commentary included in this report sets out our reasons for this warning.

Results

The following results are those gained from Version 6.2.2.

Whole Orchard and Farm Overseer results (kg N / ha / yr)

	Minimum	Average	Maximum
Pipfruit	7	13	26
Kiwifruit*		25	
Vegetable	5	16	47**

The results of the management questions are included in the body of this report.

A summary of the financial analysis is in the table below.

	Min	Ave	Max
Pipfruit			
Total Revenue	23,017	91,619	154,050
Total Production Costs	20,106	49,890	68,792
Earnings Before Interest and Tax	2,911	41,728	85,258
Kiwifruit			
Total Revenue		127,852	
Total Production Costs		47,869	
Earnings Before Interest and Tax		79,983	
Vegetable Growers			
Total Revenue	5,612	20,957	57,000
Total Operating Expenses	3,775	12,125	25,969
Earnings Before Interest and Tax	470	8,832	31,031

A summary of the economic efficiency measures calculated for the data collected in this survey are shown in the table below.

Economic Efficiency measures. (output per unit of N leaching)

	Min	Ave	Max
Pipfruit			
Total Revenue	885	8,610	16,446
Earnings Before Interest and Tax	112	3,922	9,181
Kiwifruit			
Total Revenue		5,187	
Earnings Before Interest and Tax		3,080	
Vegetable Growers			
Total Revenue	621	1,432	3,191
Earnings Before Interest and Tax	41	516	1,684

2 Background

This report discusses the background to the commissioning of the survey of both Orchards and Vegetable Growing operations in the Hawkes Bay. It then goes on to explain the methodology of both the data collection and the analysis carried out and then reports the results.

We must thank the twenty eight growers who participated in this survey for the time that they took to answer our questions and the willing way in which they shared both information on their growing operation and their financial performance. We appreciate that much of this information was shared with us in the knowledge that it is to be held as confidential. Accordingly all of the information which is reported here is reported in a form which protects the confidential nature of individual data.

2.1 Commissioning

This survey was commissioned by Horticulture New Zealand (HortNZ) and the Hawkes Bay Regional Council (HBRC). HortNZ wished to understand the absolute values and the ranges of values amongst growers in the Hawkes Bay as to N leaching and the financial performance which was being achieved by growers in the region. HBRC wished to gain values which they could use in their region wide modelling of the losses of N and P.

2.2 Methodology

This methodology section describes the gathering of the information through the survey technique and the analysis of that information.

2.2.1 The Survey

The survey instrument used was in an Excel format which was filled out by the interviewer during the visit to the grower. It had three sections:

- Questions into the **growing operation** which were sufficient to be able to model the operation in Overseer Version 6.2.2 using the Best Management Practice for Data Entry Standards. These included questions on the location and soil type, orchard / crop mix, the timing of key operations including the yield of the crop, the type and timing of fertiliser applications and the capacity of the irrigation system.
- Questions as to the **management practices** carried out on the farm which was designed to test whether the grower was operating at good or best management practice. These included questions on soils, cultivation, fertiliser, irrigation and other practices carried out on the farm.
- The **financial performance** of the operation which detailed the financial performance of each individual variety or crop.

In total there were twenty eight surveys carried out so the number interviewed were a representative sample rather than a highly significant statistical sample. Half of these were carried out by AgFirst who interviewed the pipfruit growers and half were carried out by The AgriBusiness Group who interviewed the vegetable growers. Selection of the people to be interviewed was carried out to achieve two aims. The first was to get a good representation of the range of growers in terms of the size and scope of their operations. The second was to get a good representation of the overall growing operation in the Hawkes Bay to allow HBRC to use the data in their modelling.

2.2.2 Analysis

The data was analysed in three ways.

Growing Operation

The data gained from the growing operation questions were used to create individual Overseer models for each growers operation. Please note that because the crop mix could not be fully or accurately modelled on Overseer, three of the vegetable operations are not represented in the results.

Management Practices

The results from the management practices part of the survey are reported as to whether the interviewee had a positive (yes) response or a negative (no) response or whether the question was not applicable to their situation.

Financial Performance

The financial data which was collected on an individual variety or crop basis was rated up to reflect the performance of the business as a whole. This was reported in the format shown in Table 1. This reflects the fact that the two sections of the industry had their financial data collected under slightly different headings. It also reflects the fact that the orchard industry has to pay a significant amount of the post harvest costs of handling their produce whereas the vegetable sector does not.

Table 1: Financial performance reporting headings.

Orchard	Vegetable
Total Revenue	Total Income
Total post harvest expenses	Variable Costs
Total labour expenses	Fixed Costs
Orchard operating expenses	Total Operating Expenses
Total administration expenses	Earnings Before Interest and Tax
Total Production Costs	
Earnings Before Interest and Tax	

In order to reflect the economic efficiency of the various operations Total Revenue and Earnings Before Interest and Tax have both been divided by the N leaching result of the operation to reflect the financial output compared to the leaching output.

2.3 Caution on the Use of Overseer

We believe that considerable caution should be used in the use of nutrient benchmarking results produced in Overseer for the Horticultural industry. The following commentary sets out our reasons for this warning.

It is HortNZ's policy to work with Overseer to try and improve the accuracy of the N leaching figures produced by the tool. However when Councils seek to use Overseer as a tool to aid their legislative intentions in the vegetable sector HortNZ has some serious doubts about Overseers ability to accurately predict the performance of the sector.

In the report written by The AgriBusiness Group "Nutrient Performance and Financial Analysis of Lower Waikato Horticulture Growers" the authors identified a number of challenges related to modelling vegetable crops in Overseer which had a potential negative effect on our ability to accurately model the N leaching performance of the vegetable growing sector. In that report it commented on a review carried out by FAR of the use of Overseer in the Arable and Horticultural sector as follows:

The Foundation for Arable Research[1] carried out an independent review of the use of OVERSEER in the arable sector, which incorporated consideration of the horticultural sector. It came up with the following conclusion:

OVERSEER® is the best tool currently available for estimating N leaching losses from the root zone across the diversity and complexity of farming systems in New Zealand. This review sets out a pathway for improving its fitness for this purpose in the arable sector (see recommendations). It also highlights that the new challenges facing OVERSEER® place demands on the development team and model owners that need to be acknowledged and resourced appropriately.

The review came up with the following recommendations which are relevant to the horticultural sector:

OVERSEER® crop model estimates of N leaching should be evaluated against measurements of N leaching to identify whether there are any systematic errors in predictions.

We note that this has been the subject of new projects facilitated and led by HortNZ and the Foundation of Arable Research through the "Rootzone Reality" Programme establishing a national network of lysimeters. Of direct relevance is the extension of this project in partnership with Auckland Council and Waikato Regional Council. The extension has led to a series of additional trial sites where groups of fluxmeters have been installed under cropping land in Pukekohe, Pukekawa and Matamata to directly measure nitrogen discharges below the rootzone. The work was commenced in 2014 with installation of sites. It will take at least 3-4 years to establish measurements that are useful. It will take additional time for the OVERSEER® owners to incorporate the new information into modelling predictions.

OVERSEER® crop model estimates of N leaching should be evaluated against predictions of longterm leaching produced by established, detailed research models e.g. APSIM.

Horticulture New Zealand, Foundation for Arable Research and the Fertliser Association of New Zealand has a contract with Plant and Food Research to test Overseer results in comparison with APSIM. The project has been implemented (start in early 2015) and is projected to deliver in October 2016. It will take additional time for the OVERSEER® owners to incorporate the new information into modelling predictions.

The testing outlined in recommendations (1) and (2) is likely to identify and justify areas for further development of OVERSEER® to improve N leaching predictions.

As far as we are aware none of the three recommendations made in that report have been completed. This is at least partially due to the development of Overseer being limited by the

[1] FAR (2013) : A peer review of OVERSEER in relation to modelling nutrient flows in arable crops.

expenditure of capital and partially due to the low priority put on the development of vegetable production capability by Overseer.

So we still do not know whether there is any justification for the crop model estimates being used by Overseer and we have not had them verified by comparison to other means of modelling (APSIM).

Apart from the basic uncertainty around the accuracy of the crop model estimates used in Overseer there are also concerns about:

- The gross nature of the inputs used in entering data into Overseer (monthly data is the finest input timeframe) which are unable to accurately reflect the complexities of relatively fine scale vegetable production systems and

- The fact that Overseer is not currently capable of modelling all possible crop types. In a recent paper written for ECan (Hume)[2], Plant and Food identified that approximately half of the crops sown were not named as options in Overseer in an exercise in crop modelling in Canterbury. We would assume that this figure would be even more extreme in the high producing Waikato vegetable growing sector.

- The fact the Overseer is a long term averaging tool which has a fixed, and somewhat limited, array of long term climatic data which it uses to spread the climatic data entered over, which represents an average of thirty years data.

In the Hume paper it identified that there were a total of 21 complexities that they encountered when modelling horticultural properties in Overseer. For each one they had to develop "work arounds" to try and accurately come up with an N leaching figure which was best able to report the estimates made by Overseer. A list and brief description of each of the work arounds is in Appendix 1.

In summary they said:

Councils using OVERSEER® for regulatory purposes should consider the listed issues and, along with industry bodies (e.g. HortNZ and FAR), inform growers with guidelines and expectations for the modelling of their farms to ensure consistency of outputs across the industry.

The reliability and accuracy of Overseer in its current state must also be in question. A new version of Overseer became available just as this report was being prepared but after the Overseer modelling had been completed. This version change was primarily made up of fixes to some of the known modelling errors. When all of the models were opened in the new version of Overseer one third of the orchards and one half of the vegetable properties had changes, both up and down, to their N leaching figures. These are changes that have come about as a result of the known errors in Overseer.

[2] Hume et al 2015. MGM Technical Report Arable and Horticultural crop modelling**.** Report written by Plant and Food for ECan.

3 Results

3.1 Overseer Results

The following results are those gained from Version 6.2.2.

Table 2: Whole Orchard and Farm Overseer results (kg N / ha / yr)

	Minimum	Average	Maximum
Pipfruit	7	13	26
Kiwifruit*		25	
Vegetable	5	16	47**

* There were only two kiwifruit orchards surveyed so to protect their information only the average is reported.

** The highest recording for a vegetable grower came from a property which grew both summer and winter leeks. It is not possible to model leeks in Overseer so a substitute crop was chosen. Caution should be taken in using this result because we have no idea whether the substitute crop accurately reflects the performance of leeks.

For the vegetable growers it is possible to report the individual results of the crops grown. A crops result for Nitrogen leeching can be influenced by a huge number of factors including, the total rotation which it is in, the crop which it follows, the provision or absence of a cover crop during the winter previously, whether it is an autumn sown or spring sown crop, the cultivation technique used, the amount of N applied and the nature of the soil type on which it is grown etc, etc.

Table 3: Individual crop Overseer results (kg N / ha / yr)

	Number	Minimum	Average	Maximum
Onions (white)	4	23	25	28
Onions (brown)	1	41	41	41
Tomatoes	3	5	6	7
Beetroot	2		15	
Squash	5	10	17	37
Maize	7	7	9	21
Sweetcorn	7	5	10	27
Spinach	1	21	21	21
Peas / Beans	3	5	6	7
Melon	2		16	
Pumpkin	2		22	
Leeks*	2		48	
Potatoes	1	6	6	6

* see comments on the modelling of leeks in the Table above.

3.2 Management Questions

3.2.1 Vegetable Growers Responses

Good Management Practices

Soils	Yes	No	Not Applicable
Undertake a paddock assessment and plan to ensure that appropriate GMPs and BMPs are selected	11	0	2
Choosing appropriate crop	10	0	2
Estimate the residue from the previous crop and any carry over nitrogen such as through the crop not yielding full potential?	9	2	2
Soil testing is conducted on each paddock/Block every 3-5 years	10	1	0
Soil testing uses a uniform or representative collection pattern	10	0	1

Cultivation	Yes	No	Not Applicable
Cultivate soil when conditions appropriate. Minimise soil tillage as much as practicable.	9	0	4
Plant a row of grain or a cover crop at appropriate intervals as a shelter belt to prevent wind erosion of soil.	4	1	8
Consider contour farming e.g. using contour farmed rows as a headland in front of creeks and drains	3	1	9
Use riparian margins or buffer strips beside streams and drains	4	1	8
Methods are used to minimize sediment runoff	3	0	8
Manually assess soil for compaction relative to crop rooting depth and take appropriate action	11	0	2

Fertiliser	Yes	No	Not Applicable
Plan fertilizer inputs for the crop - both base and side dressings - based on scientific evidence that is available or informed by fertilizer recommendations	11	0	1
Take into account any organic manures used e.g. chicken manure, mushroom compost	7	1	5
Take into account any animals in the rotation	6	2	5
Applications of N are managed to taking into account rainfall, field capacity and soil saturation levels	10	0	3
Fertiliser should be stored and loaded to avoid spillages into waterbodies.	5	1	7
Calibrate fertilizer spreading equipment - simple method	11	0	2
Nutrient applications are informed by available information or fertilizer recommendations	13	0	0
Fertiliser applications are applied relative to the predicted uptake levels of the plant from planting to maturity	12	0	1
Fertiliser spreading equipment is calibrated and can accurately deliver the recommended treatment	10	2	1
Side dressings used to reduce risk	6	3	3

Irrigation	Yes	No	Not Applicable
Plan irrigation requirements	11	1	1
Irrigators are calibrated	9	1	2
Volumes applied informed by relevant factors e.g. Plant growth/ stage/ soil type/ water holding capacity and climatic conditions	9	2	2
Water is applied to maintain soil moisture between the wilting point and field capacity where possible	9	2	2
Irrigation efficiency is measurable at greater than 80%	5	3	4
Water is metered	11	0	1

Other Practices	Yes	No	Not Applicable
Use of Cover crops	9	1	3
Remove as much harvestable crop as possible	13	0	0
Remove or incorporate crop residues where possible	11	0	2
Competency and training of operators	11	0	2
Maintain records of activities and applications undertaken	13	0	0

Best Management Practices

Soils	Yes	No	Not Applicable
Soil testing is conducted on each paddock every year when a crop is going to be planted	5	5	2
Nutrient levels are managed according to rainfall, informed by deep N testing and will match likely yield and quality goals.	3	5	4

Cultivation	Yes	No	Not Applicable
Assess soil for compaction using a penetrometer	7	4	1
Adoption of new technology	7	1	3

Fertiliser	Yes	No	Not Applicable
Calibrate fertilizer spreading equipment - more complex	7	3	1
Obtain advice from a Nutrient Fertiliser Advisor or agronomist	10	2	0
Use improved fertilizer technology where appropriate (e.g. prills/coatings)	5	6	0
Controlled traffic farming technology to increase application efficiency and soil management.	5	2	4
Advanced farming systems that make use of GPS mapping and aerial photography	1	1	0
Proof of operator following management instructions for application, including avoiding spreading into water bodies	6	1	5
Crop calculators may be used if available and practical for local conditions	4	2	5

Nutrient levels are managed according to rainfall/ irrigation, informed by deep N testing and will match likely yield and quality goals	3	7	2
Leaf tests are conducted	9	2	0

Irrigation	Yes	No	Not Applicable
Irrigation scheduling is undertaken using a crop model or tied into a soil moisture monitoring system	4	7	1
On site soil moisture monitoring is conducted	7	4	1
Irrigation is variably applied within the paddock to maximize efficiency	2	9	1
Highly automated irrigation systems that allow more frequent applications of less water are used to maximize efficiency	0	11	1

Other Practices	Yes	No	Not Applicable
Technology More efficient machinery	7	5	0
Technology GPS used to monitor operator performance	6	5	0
Industry advice-Independent agronomic advice	5	7	0
Accredited contractors/ suppliers Spreadmark accredited contractors	7	3	0
Industry programmes. Assure, Global Gap	10	1	0

3.2.2 Orchardists Responses

Good Management Practices

Soils	Yes	No	Not Applicable
Undertake a paddock assessment and plan to ensure that appropriate GMPs and BMPs are selected	11	1	0
Choosing appropriate crop	5	3	0
Estimate the residue from the previous crop and any carry over nitrogen such as through the crop not yielding full potential?	4	5	0
Soil testing is conducted on each paddock/Block every 3-5 years	10	0	0
Soil testing uses a uniform or representative collection pattern	10	0	0

Cultivation	Yes	No	Not Applicable
Cultivate soil when conditions appropriate. Minimise soil tillage as much as practicable.	6	3	0
Plant a row of grain or a cover crop at appropriate intervals as a shelter belt to prevent wind erosion of soil.	2	4	0
Consider contour farming e.g. using contour farmed rows as a headland in front of creeks and drains	0	5	0

Use riparian margins or buffer strips beside streams and drains	1	1	0
Methods are used to minimize sediment runoff	6	0	0
Manually assess soil for compaction relative to crop rooting depth and take appropriate action	2	6	0

Fertiliser	**Yes**	**No**	**Not Applicable**
Plan fertilizer inputs for the crop - both base and side dressings - based on scientific evidence that is available or informed by fertilizer recommendations	9	0	1
Take into account any organic manures used	2	5	0
Take into account any animals in the rotation	2	4	0
Applications of N are managed to taking into account rainfall, field capacity and soil saturation levels	10	1	0
Fertiliser should be stored and loaded to avoid spillages into waterbodies.	9	1	0
Calibrate fertilizer spreading equipment - simple method	5	4	0
Nutrient applications are informed by available information or fertilizer recommendations	9	0	0
Fertiliser applications are applied relative to the predicted uptake levels of the plant from planting to maturity	8	0	0
Fertiliser spreading equipment is calibrated and can accurately deliver the recommended treatment	8	0	0
Side dressings used to reduce risk	3	0	0

Irrigation	**Yes**	**No**	**Not Applicable**
Plan irrigation requirements	12	0	0
Irrigators are calibrated	11	0	0
Volumes applied informed by relevant factors	12	0	0
Water is applied to maintain soil moisture between the wilting point and field capacity where possible	11	0	0
Irrigation efficiency is measurable at greater than 80%	11	0	0
Water is metered	11	0	0

Other Practices	**Yes**	**No**	**Not Applicable**
Use of Cover crops	12	0	0
Remove as much harvestable crop as possible	12	0	0
Remove or incorporate crop residues where possible	9	0	0
Competency and training of operators	11	0	0
Maintain records of activities and applications undertaken	11	0	0

Best Management Practices

Soils	Yes	No	Not Applicable
Soil testing is conducted on each paddock every year	7	2	0
Nutrient levels are managed according to rainfall, informed by deep N testing and will match likely yield and quality goals.	4	3	0

Cultivation	Yes	No	Not Applicable
Assess soil for compaction using a penetrometer	3	5	0
Adoption of new technology	4	6	0

Fertiliser	Yes	No	Not Applicable
Calibrate fertilizer spreading equipment - more complex	7	2	0
Obtain advice from a Nutrient Fertiliser Advisor or agronomist	8	2	0
Use improved fertilizer technology where appropriate (e.g. prills/coatings)	5	4	0
Controlled traffic farming technology to increase application efficiency and soil management.	6	3	0
Advanced farming systems that make use of GPS mapping and aerial photography	1	0	0
Proof of operator following management instructions for application, including avoiding spreading into water bodies	7	2	0
Crop calculators may be used if available and practical for local conditions	6	3	0
Nutrient levels are managed according to rainfall/ irrigation, informed by deep N testing and will match likely yield and quality goals	6	3	0
Leaf tests are conducted	9	0	0

Irrigation	Yes	No	Not Applicable
Irrigation scheduling is undertaken using a crop model or tied into a soil moisture monitoring system	11	0	0
On site soil moisture monitoring is conducted	10	0	0
Irrigation is variably applied to maximize efficiency	6	3	0
Highly automated irrigation systems that allow more frequent applications of less water are used to maximize efficiency	8	1	0

Other Practices	Yes	No	Not Applicable
Technology More efficient machinery	9	0	0
Technology GPS used to monitor operator performance	6	6	0
Industry advice-Independent agronomic advice	12	0	0
Accredited contractors/ suppliers	10	0	1
Industry programmes. Assure, Global Gap	11	0	0

3.3 Financial Results

The minimum, average and maximum results of the financial results for the Orchards are shown in Table 4. The first three columns report the results for the Pipfruit orchards the next column reports the average result for the Kiwifruit orchards.

Table 4: Financial performance of the Orchards ($ / ha).

Orchard	Min	Ave	Max	Min	Ave	Max
Total Revenue	23,017	91,619	154,050		127,852	
Total post harvest expenses	5,409	27,159	42,890		21,445	
Total labour expenses	7,726	15,385	19,064		16,567	
Orchard operating expenses	5,376	6,296	7,241		8,950	
Total administration expenses	468	1,271	1,554		906	
Total Production Costs	20,106	49,890	68,792		47,869	
Earnings Before Interest and Tax	2,911	41,728	85,258		79,983	

Table 5 reports the results for the vegetable growing operations.

Table 5: Financial performance of the Vegetable growers ($/ ha).

Vegetable Growers	Min	Ave	Max
Total Income	5,612	20,957	57,000
Variable Costs	2,723	10,386	24,222
Fixed Costs	562	1,739	3,674
Total Operating Expenses	3,775	12,125	25,969
Earnings Before Interest and Tax	470	8,832	31,031

The economic efficiency measures are reported in Table 6.

Table 6: Economic Efficiency measures. (output per unit of N leaching)

	Min	Ave	Max
Pipfruit			
Total Revenue	885	8,610	16,446
Earnings Before Interest and Tax	112	3,922	9,181
Kiwifruit			
Total Revenue		5,187	
Earnings Before Interest and Tax		3,080	
Vegetable Growers			
Total Revenue	621	1,432	3,191
Earnings Before Interest and Tax	41	516	1,684

Appendix 1: Quote from Hume report on modelling Horticulture in Overseer.

The following (1–21) are some examples of complexities that were encountered during the modelling in OVERSEER® and assumptions that were made. For each circumstance, the limitation is documented and the approach taken to address the limitation is detailed. This information was shared with OVERSEER® management to support future model improvements.

1. Substitute crops

Limitation: OVERSEER® is not currently capable of modelling all possible crop types grown in NZ. The crop types it does not specifically model are generally specialist vegetables or high value non-herbage seed crops. There is limited research knowledge around the growth and N status of these crops and the area grown in NZ cropping systems is comparatively small.

2. Double-sown crops

Limitation: Double-sowing of crops is a management practice that happens on-farm but cannot be modelled in OVERSEER®; more than one crop management option per month is not allowed therefore multiple crops cannot be grown concurrently.

3. Altering crop growth

Limitation: OVERSEER® assumes a default growth curve and harvest date for each crop which did not always match how growers managed their rotations. For example, this could be due to timing differences between varieties, or practices such as spraying off the tops of root vegetables and then storing in the ground for the following months.

4. Yield units

Limitation: OVERSEER® requires crop yields to be specified in tonnes per ha. However, some crops such as vegetables are counted by other units (e.g. number of heads, cobs, bunches in a crate) and thus growers could not always provide a yield in the appropriate units.

5. Crop failures

Limitation: In reality crops may fail in the field, resulting in poor yields or even a non harvestable crop. This is a particular problem for small scale horticultural crops. OVERSEER® does not model crop failure rates for crop blocks.

6. Monthly inputs

Limitation: Decisions had to be made on how to translate fine-scale (e.g. daily) crop management records into the monthly application scale that OVERSEER® works at. For example, in reality a grower may harvest a crop on 10 March and sow another on 24 March but multiple management actions (e.g. harvesting a crop and sowing another) within a month cannot be modelled in OVERSEER®.

7. Grazing

Limitation: For farms that graze stock for part or all of the year (e.g. mixed cropping/pastoral farms), unless the whole farm is modelled (not just crop blocks) stock enterprises cannot be modelled due to feed requirements of stock not being met in OVERSEER®. Many of the growers used imported animals to clean up blocks, but some also specialised in the buying and selling of animals, for example store lambs over winter.

8. Part paddock grazing

Limitation: OVERSEER® assumes even distribution of animals over a block that is being grazed. However in reality forages and fodders are likely to be break-fed.

*9. **Residue management options***

Limitation: OVERSEER® cannot model multiple residue management options for a single crop. There is also an assumption in the model that all forages, fodder, green manure and permanent pasture crop types have residues retained.

10. Grazing residues in months post-harvest

Limitation: OVERSEER® does not model grazing of crop residues in months following the final harvest month of a crop (e.g. cleaning up grain stubble and weeds). No animals can be on the block in months where there is no actual crop.

11. Sequential planting and harvesting

Limitation: A specific limitation for horticultural growers using OVERSEER® is the inability to model sequentially planted and harvested crops. This is because management inputs and reporting in the model occur at a whole block level. Crops in the survey that had staggered sowing dates (to varying extents) included broccoli, brussel sprouts, cabbage, carrots, cauliflower, leeks, onions, pak choi/shanghai, silverbeet, spinach, spring onions and sweetcorn.

12. Multiple vegetable harvests

Limitation: There are no harvest options in OVERSEER® for multiple harvests of vegetables crops, e.g. silverbeet in the survey was picked multiple times.

13. Irrigation

Limitation: Information collected from surveyed growers on irrigation included some or all of the following: irrigator type, return period, maximum application depth, number of applications and total seasonal application amount. These factors depend on seasonal conditions, water availability and farm-wide soil moisture priorities. Due to the long-term annual average climate data used in OVERSEER®, applying actual irrigation amounts was not seen as appropriate for the purposes of capturing typical rotation management and nutrient losses in Canterbury.

14. Nutrients

Limitation: Growers tend to use soil nutrient testing in autumn to determine fertiliser applications required for optimal plant growth in the coming season. However, rather than entering a soil mineral N test value in OVERSEER®, N available for plant growth from the various soil N pools is calculated based on management descriptions of the land use prior to the reporting year and long-term annual average conditions. Therefore, actual fertiliser applications may not align with what is required for the OVERSEER® modelled crops.

15. Variable rate management

Limitation: OVERSEER® cannot model variable rate fertiliser or irrigation applications as management occurs at a block scale.

16. Cultivation

Limitation: The options for cultivation in OVERSEER® (direct drilled, minimum till and conventional) are coarse in comparison with actual practices in cropping systems. The restriction of one management event modelled each month also limits the ability to accurately capture effects of cultivation on residue breakdown and nitrogen mineralisation.

17. Prior land use

Limitation: Land use prior to the two year rotation in the block is a modelled input in OVERSEER®, however the options are limited to pasture, fallow, grain crop, vegetable crop, first year of seed crop and second year of seed crop. OVERSEER® makes assumptions on most of the management of these prior crops. For example, the month of crop end is assumed by the model with grain and vegetable crops tending to 'end' earlier than required.

18. Long-term paddock history

Limitation: OVERSEER® requires the total number of years in pasture three to 12 years prior to the reporting year in the block to be recorded. This value affects the N mineralisation rate in the block, but was not always known or recorded in the farm surveys.

19. Variable and small crop areas

Limitation: A complexity particularly characteristic of horticultural growers is the fluidity of 'paddock' boundaries. Often small areas of crops are grown (e.g. 0.2 ha) or varying sized areas are used throughout the year for different purposes as space becomes available. Figure 3 shows a simple example of the dynamics of changing crop areas across consecutive seasons. OVERSEER® is currently designed to model larger areas and even combine paddocks into single blocks in the model based on similarities in soil, crop rotation and management of that rotation.

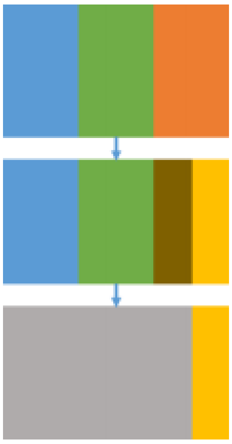

Figure 3: Simplified representation of how crop areas grown (therefore 'paddock' boundaries) may change across three consecutive seasons of the year. Each colour represents a different crop grown.

20. Leased blocks

Limitation: It is common for horticultural growers in particular to move disease-prone crops such as potatoes and broccoli around leased pastoral blocks. Complete paddock history is not always available, creating challenges for representing these situations in OVERSEER®.

21. Soil and climate information

Limitation: Growers provided basic soil information for the surveyed farms, but multiple soil types could occur across the blocks. OVERSEER® models long-term (30 year) annual average climate patterns which is information that a grower is unlikely to be able to provide.

While the principles for resolving the limitations of OVERSEER® modelling of crop blocks apply to both the horticultural and arable industries, the majority of them were issues more specific to the horticultural survey farms. Growers, particularly those in horticulture, have very dynamic, responsive management and rotation structures depending upon multiple factors (e.g. market and industry demand and prices, environmental conditions, crop establishment and health throughout growing season, disease and weeds, seasonal yields, and stock availability). The assumptions above allowed the consistent summarisation of 'typical' current practices in Canterbury within the constraints of the OVERSEER® model. Councils using OVERSEER® for regulatory purposes should consider the listed issues and, along with industry bodies (e.g. HortNZ and FAR), inform growers with guidelines and expectations for the modelling of their farms to ensure consistency of outputs across the industry.