FOUNDATION FOR ARABLE RESEARCH

FAR®

Arable Research in Action

Wednesday 6 December, 2017

FAR Arable Research Site

Chertsey

11.00am – 4.00pm

ARIA

Arable Research In Action 2017

On behalf of the Foundation for Arable Research, welcome to ARIA: Arable Research in Action, 2017.

We hope that you make the most of this opportunity to view a range of FAR trials and hear up-to-date research findings from New Zealand and overseas experts.

We have worked hard to create a programme covering a range of crops and management issues, and encourage you to participate fully in all discussions and deliberations. The aim of this day is to provide you with information and ideas that will help you to solve problems and create new opportunities in your cropping business. Presentation titles and speakers are outlined over the page, and summaries can be found further on in the booklet.

What's on?

The programme and map over the page outline the times and locations of all of today's presentations. Each speaker will give their presentation twice - once in the morning, and again in the afternoon. Each talk is around 20 minutes long and will be followed by time for questions and discussions. There will also be the chance to talk to speakers at lunch time and at the end of the day.

Lunch and end of day barbecue

Lunch will be available from the large marquee after the morning presentations finish at 1.00pm.
A barbecue and refreshments will be served immediately after final presentations at 4.00pm.

Questions?

Should you require any assistance throughout the day, please don't hesitate to contact a member of the FAR team who will be more than happy to help.

We are confident that you will leave the event with new information to assist you in making critical farm management decisions and to improve the economic and environmental performance of your crop production system.

Enjoy your day.

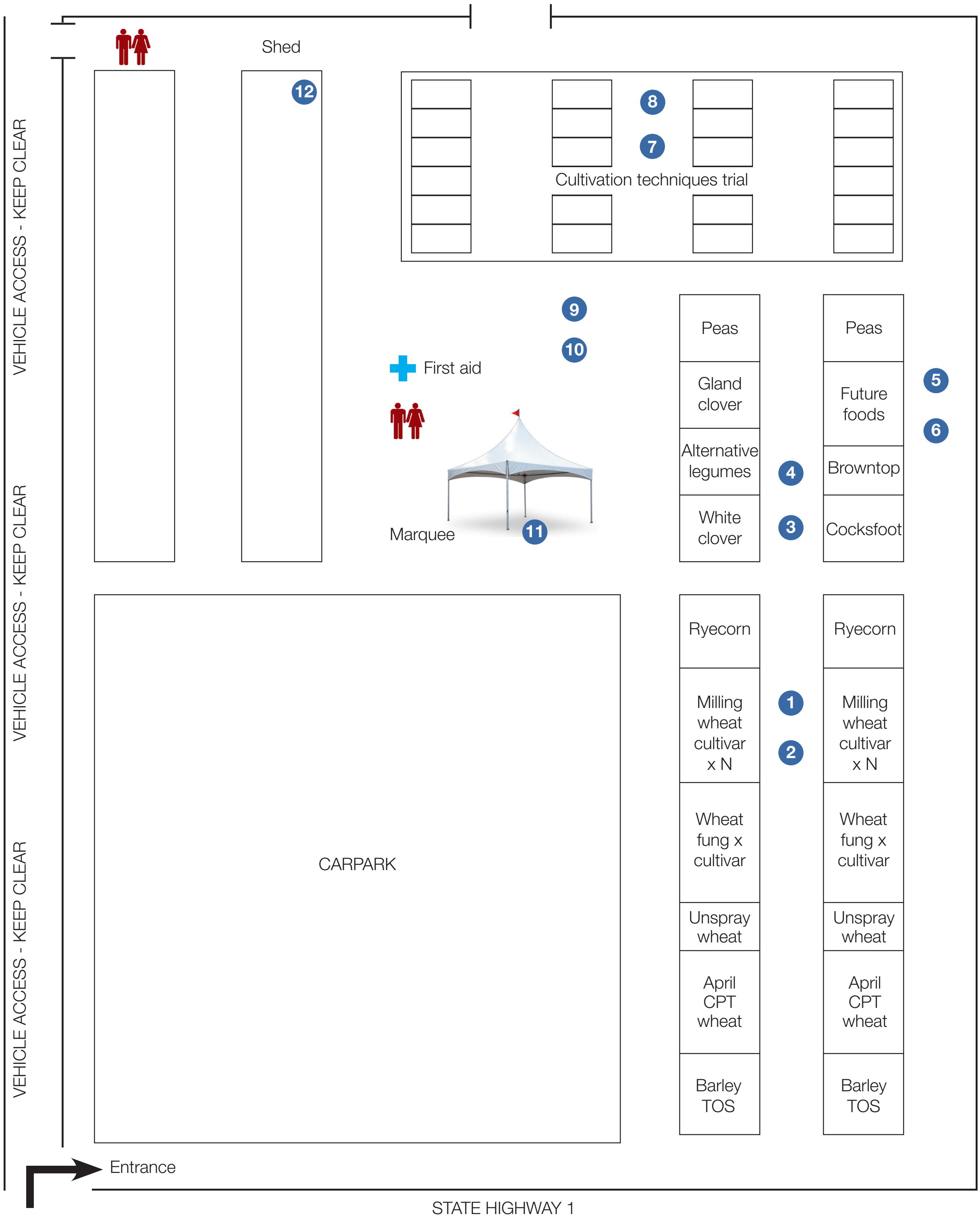
The FAR Team

ADDING VALUE TO THE BUSINESS OF CROPPING

ARIA

Arable Research In Action 2017

Site plan



FAR

Topics and Speakers

1.	Nitrogen on milling wheat.	Garth Gillam, Champion Flour Mills and Rob Craigie, FAR
2.	The new Quick N test for use in potatoes and other crops.	Jen Linton and Diana Mathers, FAR
3.	Irrigation of grass seed crops.	Richard Chynoweth and Phil Rolston, FAR
4.	Seed production from alternative legumes.	Richard Chynoweth and Phil Rolston, FAR
5.	Crops for the future.	Nick Pyke and Matilda Gunnarsson, FAR
6.	Cropping sequences – where have we come from, what's important for the future?	Nick Poole, FAR
7.	Reducing nitrous oxide emissions in broad acre cropping.	Michael Straight, FAR and Steve Thomas, Plant & Food Research
8.	Tillage and crop rotation – impacts on soil quality.	Abie Horrocks, FAR and Craig Tregurtha, Plant & Food Research
9.	Grain storage techniques to protect grain quality.	Peter Botta, PCB Consulting, Australia and Joanne Drummond, FAR
10.	Making precision agriculture pay.	Allister Holmes, FAR
11.	Environmental update for cropping – look how far we have come.	Diana Mathers, FAR
12.	Biosecurity and the cropping industry.	Nick Pyke, FAR

Schedule

11.00am	11.30am	12.00pm	12.30pm	1.00pm	1.30pm	2.00pm	2.30pm	3.00pm	3.30pm	4.00pm
1						1				
4						4				
11						11				
	2						2			
	7						7			
	9						9			
		3		Lunch in marquee				3		Drinks
		5						5		
		8						8		
			6						6	
			10						10	
			12						12	

Nitrogen management for yield and quality in milling wheat crops

Rob Craigie, FAR and Garth Gillam, Champion Flour Milling

Key points

- Knowledge quantifying the rate of N mineralisation due to variation in soil type, soil moisture, soil temperature and crop rotation is limited.
- N response trials provide data that can inform N management.
- On average, FAR N trials show about 30 kg of N (soil mineral (0 to 60 cm depth) + applied) is required for each tonne of grain to maximise yield.
- Depending on the cultivar, an additional application of 40 kg N/ha at ear emergence may be needed to meet the 11% minimum protein specification.
- The millers and bakers have been working together over the past six months on a project called *Flour fit for purpose.*
- A trial has been set up in order to gain a better understanding of the impacts of nitrogen rate and timing on flour protein quality and quantity.

Milling wheat nitrogen management

The crop nitrogen (N) demand or the amount of N removed by wheat crops is easily measured. An 11 t/ha milling wheat crop with a protein content of 12% will remove about 300 kg N/ha (Table 1). However, calculating the amount of N to apply to maximise yield is not so easy because of uncertainty in measuring soil N supply. Although the amount of soil mineral N available in early spring can be measured, the amount of N that will be mineralised during stem extension when the crop has the highest N demand is uncertain. Knowledge quantifying the rate of N mineralisation due to variation in soil type, soil moisture, soil temperature and crop rotation is limited.

Table 1. Nitrogen removal (kg N/ha) by an 11 t/ha milling wheat crop with 12% protein.

	Canopy N (kg/ha)
Grain	230
Straw	70
Total	300

N response trials provide data that can inform N management. FAR irrigated milling wheat N guidelines (see FAR Cropping Strategies: Nitrogen application in wheat and barley, 2013) are based on 10 on-farm trials over the past 10 years (Table 2).

- On average, FAR trials show about 335 kg N/ha (soil mineral N (0-60cm) + applied N) maximises yield. For cultivar Conquest this amount of N will also deliver high protein. In contrast, for the gristing cultivar Amarok, an additional application of 40 kg N/ha at ear emergence may be needed to meet the 11% minimum protein specification.
- The average applied N dose for maximum yield was about 230 kg N/ha (range 108 to 340 kg N/ha). Applied N rates of over 200 kg N/ha were optimum in seven of ten trials.
- On average, FAR N trials show about 30 kg of N (soil mineral (0 to 60 cm depth) + applied) is required for each tonne of grain to maximise yield. Depending on the cultivar an additional application of 40 kg N/ha at ear emergence may be needed to increase the protein by about 0.5% to ensure the minimum protein specification (11%) is met. Soil mineral N is assumed to be 100% available. No account is taken of subsequent N mineralisation during the growing season. The amount of N required to maximise yield may vary due to variability in N mineralisation. This method of N budgeting also has the disadvantage of needing to forecast the yield.

Table 2. Summary of four nitrogen (N) rate response trials on irrigated milling wheat cv Conquest and six trials on cv Amarok including mineral soil N (0-60 cm), optimum applied and total available N rates for the optimum grain yield response, protein and NUE.

Cultivar	Min N	Optimum N		Grain Yield			NUE
	0-60 cm	Applied	Total	Nil	N opt	Protein	Soil + applied N
	(kg/ha)	(kg/ha)	(kg/ha)	(t/ha)	(t/ha)	(%)	(kg N/t grain)
Conquest	95	236	332	7.6	10.9	13.3	30.4
Amarok	113	222	335	7.6	11.7	11.0	29.5

Analysis of N management in irrigated milling wheat cultivar trials in Canterbury over six seasons provides information on grower practice (Table 3). The average applied N in these cultivar trials was 225 kg N/ha which was similar to the average from the N response trials. Soil mineral N is not measured in the cultivar trials so the total N available to the crop is not known. The average yield in the cultivar trials was 10.8 t/ha with an acceptable 11.5% protein.

Table 3. Summary of N management, yield and protein from irrigated autumn sown milling wheat cultivar trials from 2010 to 2015 in Canterbury.

Trial Site	Applied N (kg/ha)	Yield (t/ha)	Protein (%)	NUE- applied N (kg N/t grain)
Dorie	228	10.9	11.9	21.5
Methven	222	10.6	11.2	21.7
Norwood	182	10.6	11.2	17.2
Wakanui	267	11.0	11.8	24.9
Average	**225**	**10.8**	**11.5**	**21.3**

Milling wheat quality

This year, the millers and bakers have been working on a project called *Flour fit for purpose*. The project was initiated because the bakers reported having trouble working dough through their baking plants. Key areas of interest are mixing time, energy inputs and moulding issues. Additionally, bakery plants are working harder with increased volumes going through their plants and need to shorten up the time for the dough making process. Some bakeries have also introduced new equipment like pressure vacuum mixers and moulding equipment.

With all these issues in mind, the project began. First we looked at the quality of the current flours and grains, as well as the different types of equipment used to test the different flours, to see if we could understand more about the inner quality of each of these flours.

The work found no real differences between the results provided by different testing equipment, which directed the investigations back to the flours. Comparisons of test results from past years with those from the present, showed that today's flours are somewhat stronger and higher in protein than they were in the past.

So, what next? We decided to look more closely at the protein quality and other characteristics of individual cultivars. The main areas of difference and interest between cultivars were protein quantity and quality, along with flour base colour and brightness.

In order to gain a better understanding of protein quality and quantity, the millers, in conjunction with FAR, have set up a trial. This trial will investigate the effect of nitrogen rate and timing on yield and the end quality of proteins and the dough characteristics produced from flour of two cultivars; Discovery and Reliance. We are also working with Plant & Food Research to understand why some cultivars with lower protein produce good quality doughs with noticeably whiter crumb textures which look whiter to the eye.

Good progress is being made. We are developing some good information to assist us to provide our bakers with wheats that will produce flours that will be fit for purpose in the coming seasons and years.

The new Quick N test for use in potatoes and other crops

Diana Mathers and Jen Linton, FAR

Key points

- Regional rules are pushing farmers to demonstrate that they are farming with good management practices.
- A nutrient mass balance is a useful way of calculating fertiliser requirements. It enables fertiliser applications to be better matched to the crop's requirements. The mass balance equation is: N Fert = Crop N Demand – Soil Min N – Soil Org N.
- Nitrate Quick Test strips can be used to estimate mineral N levels in the soil at any time during the crop's growth. They are easy to use.
- Potato results in year one were promising for a mass-balance management approach.
- At site 1, 44% less fertiliser N was applied in the mass-balance treatment with no yield penalty to the crop.
- At site 2, 55% less fertiliser was used in the mass-balance treatment and the crop reached its expected yield. However, the grower's approach, of a higher rate of N fertiliser, produced an exceptional yield of 100TFW/ha.

Why test for soil N?

Regional Council land and water plans are pushing farmers to adopt industry agreed good management practices (GMPs). Managing the N supply to the crop has become increasingly important, yield potential must be maintained and the risk of environmental losses reduced.

The industry agreed GMP for nutrient management is to balance the crop's demand for nutrients with the nutrient supply from the soil with the shortfall supplied as fertiliser.

An N mass balance budget is an efficient way to determine how much N fertiliser should be applied to the crop to achieve its potential yield. However, for the budget to be developed, estimates are required for how much N the crop will need and how much N will be supplied by the soil.

Measuring the soil N supply depends on soil testing; mineral N tests give an estimate of how much N is immediately available and AMN tests estimate the potential for N to become available in the future as organic N is mineralised.

It is useful to have quick, cheap methods for estimating soil N levels throughout the season. Previous work in New Zealand has shown that nitrate Quick Test strips can be used successfully as a cost effective and reliable substitute for the mineral N test.

Quick Test N Strips - how do they work?

The Quick N Test strips are similar to the litmus strips used for soil pH testing but are coated with a chemical which is sensitive to nitrate.

1. The testing process starts with a set of in-field soil samples, collected in the usual way.
2. These are mixed together and a 10ml subsample is taken for testing.
3. The subsample is sieved, then mixed with 30ml of calcium chloride solution to extract the nitrate from the soil.
4. After 30 minutes a Quick N Test strip is dipped into the soil solution and left for one minute for the colour to develop.
5. The colour is compared to a nitrate concentration scale and gives a measure of NO3 in mg/L in the soil solution.
6. A correction factor that takes into account bulk density, soil texture and moisture is used to convert the volumetric value (mg/L) to a gravimetric value (mg/kg), relating the result to the NO3 level in the soil.

Conversion factors which consider soil moisture, bulk density and texture are used to convert the Quick N Test nitrate values from a volumetric to a gravimetric basis, enabling a kgNO3/ha measure to be developed. These conversion factors are being developed for a range of New Zealand soils.

Nitrogen – Measure it and manage it – Year 1 results for potato growers

Two potato trial sites were established; Site 1 was located in the Manawatu, near Opiki and Site 2 was located in the Canterbury near Timaru. Both sites had come out of long term pasture. Side-dressing management was targeted. Two treatments were used;

Treatment 1 was the grower's planned amount of N, to be applied at side-dressing.
Treatment 2 was a quick test mass balance (QTMB) treatment, where the side-dressing N application was based on a mass balance budget calculation using Quick Test strips to estimate the soil N supply just prior to side-dressing. Potential yield for the mass balance equation was estimated with the Potato Calculator.

The mass balance equation is:
N Fert = Crop N Demand based on the potential crop yield – Soil Min N – Soil Org N

Results

Table 1. Nitrogen applied and yield.

Site	Treatment	Nitrogen applied (kgN/ha)				DM Yield (TDM/ha) and P Value	Fresh Yield (TFW/ha) and P Value	Plant N Uptake (kg N/ha) and P Value
		Base	Planting	Side dressing	Total			
1	Grower	0	52	27	79	12.3	57	197
	QTMB	0	52	0	52	13.3	58	190
						P = 0.31	P = 0.69	P= 0.71
2	Grower	36	48	104[1]	188	22.3	100	332
	QTMB	36	48	0	84	20.0	89	273
						P = 0.03	P = 0.04	(0.05 < P < 0.10)

[1] Split application of 47 kg N/ha and 57 kg N/ha.

At Site 1, the QTMB treatment received 44% less fertiliser N with no yield penalty to the crop.

At Site 2, 55% less N was applied in the QTMB treatment. The grower treatment yield was higher by 10.7T/h, out-performing the potential yield predicted by the Potato Calculator by 9.3T/ha. In this case, the crop demand was under-estimated for the mass-balance calculation.

Exploring nitrogen use efficiency (NUE) as an environmental indicator

Having a nutrient use efficiency indicator is useful because it enables us to make efficiency comparisons between individual crops on a farm and/or between management systems and regions.

The nutrient use efficiency indicator, NUE%, is the ratio between the amount of fertiliser N removed with the crop and the amount of fertiliser N applied, expressed as a %. It is a partial nutrient balance because it does not measure the soil nitrogen supply and removal processes but nevertheless, it can provide useful information about N management in the crop. This approach has been used successfully for the Tasmanian potato industry. It has been proposed as an agro-environmental indicator because it is based on easy to collect farm information and farmers can understand where the efficiency %s have come from.

- NUE% = N removed by the crop (relates to crop yield) / N applied as fertiliser x 100.
- It can be calculated for individual crops, the paddock rotation and/or the whole farm.
- NUE% approach relies on data that is easily recalled by farmers, i.e. crop yield and nitrogen fertilisers applied. It can be used to compare groups of farmers and/or regional practices.

A high NUE% of >100% can indicate that more N is being removed than is being applied and the plants are accessing N from the organic pool or residual N from fertiliser applications to a preceding crop. It can also indicate that N is being accessed from sources other than the fertiliser, e.g. a green manure crop. It is important to establish the reason for a >100% NUE either by discussion with the farmer and/or soil testing, as depleting the organic pool can result in N deficiencies at a later stage, if not replenished. This is particularly relevant from a crop rotation perspective.

A lower NUE%, e.g. <70-60% (depending on the crop) indicates that the crop N removal is less than what has been applied. In this case, excess applied N remains in the soil and may be lost if not used by the next crop. Low NUE% could indicate excessive fertiliser use or issues with soil or crop health i.e. the crop has not grown to its potential due to lack of water, lack of other nutrients or pests and diseases, so the fertiliser programme has provided too much N.

Tasmanian Farming Futures has developed a NUE calculator which utilises the 'partial nitrogen balance' (or 'output-input ratio') method to calculate NUE% for an individual crop, a rotation or a whole farm. It can also estimate the monetary value of potentially unused mineral and organic nitrogen fertiliser.

Tasmanian farmers and advisors have used the calculator for a variety of reasons, including for verification of current best management practices, a means to assess whether or not fertiliser application is efficient and as a way to benchmark groups of producers in a region or groups growing a specific crop.

NUE objectives and questions to answer

1. Is NUE% a useful indicator for NZ potato growers?
2. What can we learn from a set of grower NUE%s?
   Is too much, not enough, or about the right amount of fertiliser being used?
3. When anything other than the right amount is being used how do farmers make their fertiliser decisions? – Opportunity to look at GMPs for nutrient management and link directly to Quick N project.
4. Is the Tasmanian tool useful for NZ growers? If so does it need to be NZ ised and what can we learn from it?

Phosphorus use efficiency

Growers are also interested in phosphorus management. It would be possible to modify the NUE tool to do a similar exercise for phosphorus use efficiency (PUE). All that is required is the P demand for potatoes and records of the phosphorus fertiliser applications. Soil Olsen P levels can be useful in giving an indication of the soil supply.

OVERSEER® is less well developed for modelling phosphorus losses, so a dataset like this will provide useful new information for potato growers.

Irrigation of grass seed crops

Richard Chynoweth, FAR

Key points

- In ryegrass, no growth stage is more sensitive to drought when quantified by the severity of drought.
- Drought severity occurs more quickly in summer compared to in early spring, giving rise to the impression that later drought is more damaging.
- Water stress, as defined by maximum potential soil moisture deficit, explains yield loss in browntop, perennial and Italian ryegrass in a similar way to wheat.
- The timing of drought within the season affects different yield components. Early season drought influences head numbers and late season drought affects thousand seed weight (number of saleable seeds).

Response to drought

Early season drought often results in a lower number of seed heads being produced at harvest; this may result from slower tiller initiation or from tiller death depending on the species and when the drought occurred. In practice this response varies from season to season depending on winter/spring rainfall. Drought later in the season reduces the number of seeds that set and the final size of those seeds, therefore minimum thousand seed weights become important.

Annual ryegrass

During the 2016/17 season seed yield of Italian ryegrass, cultivar 'Winterstar II' was reduced as drought intensity increased. Yield reductions were from an interaction between the number of seed heads and the thousand seed weight. Early drought reduced the number of seed heads while late drought reduced seed weight.

Table 1. Seed yield of 'Winterstar II' annual ryegrass grown at Chertsey with seven irrigation treatments in the 2016/17 growing season.

Treatment	Applied water (mm)	Seed heads/m^2	TSW (g)	Seed yield (kg/ha)
No irrigation	0	820	3.28	1767
Mid-season drought f.b. Replace ET	100	744	4.10	2196
Replace ET until flowering f.b. Nil	92	907	3.84	2159
Replace ET until early-seed fill f.b. Nil	132	990	3.68	2320
Replace ET until mid-seed fill f.b. Nil	162	986	3.91	2441
Replace ET	192	970	4.03	2862
50% of Full ET irrigation each week	83.5	876	3.92	2101
	Mean	899	3.82	2264
	$LSD_{0.05}$	156	0.15	390

Perennial ryegrass (*2009/10 results)*

There was a significant (P=0.02) relationship between the amount of water applied and machine dressed seed yield. For every mm of water applied, a gain of 2.3 kg of seed was returned. Maximum seed yields were achieved from treatments where greater than 205 mm of irrigation was applied with no difference between the timing/split of that irrigation (Table 2). There was no advantage to applying greater than 205 mm of water; therefore growers need to consider the economic implications of applying too much water.

Table 2. Seed yield responses of 'Grasslands Samson' perennial ryegrass to eight different irrigation treatments grown at Chertsey during the 2009/10 growing season.

Treatment	Applied irrigation (mm)	Seed yield (kg/ha)	Homogeneous groups	
Nil	0	1997		b
Replace 33% ET	102	2070		b
Replace 66% ET	205	2518	a	
Replace ET	310	2500	a	
Full until flower (early Dec) then half	227	2581	a	
Nil until flower (early Dec) then full	165	2054		b
Full until flower (early Dec) then Nil	145	1943		b
	$LSD_{0.05}$	= 290		

Browntop

In year 1, the establishment season, seed yield was limited by slow plant development reducing the number of seed heads and drought, with maximum seed yields of ~300 kg/ha achieved by three different irrigation treatments (Figure 1). In years 2 and 3, any period of water stress reduced seed yield.

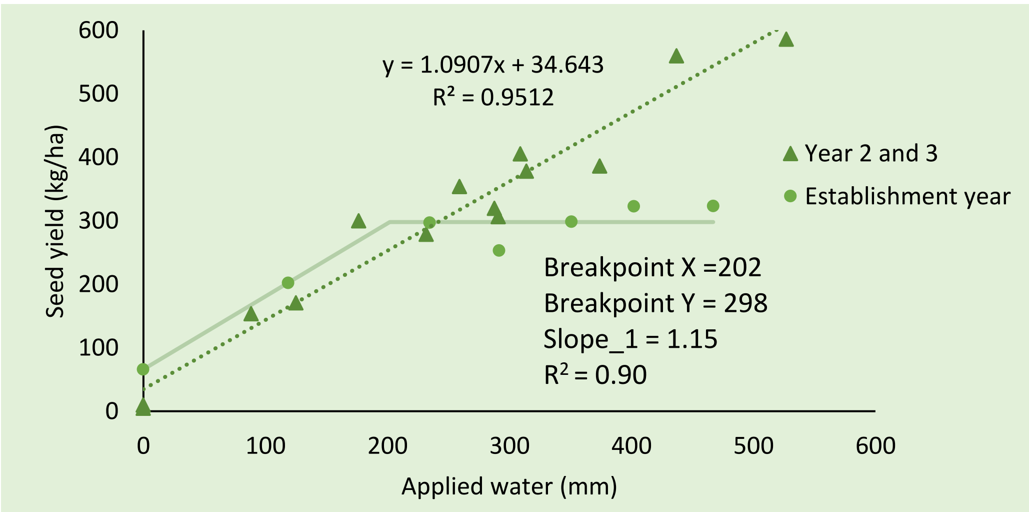


Figure 1. Seed yield response of browntop, cv 'Arrowtown' to various rates and timings of irrigation grown for three seasons at the FAR Arable Research Site, Chertsey, Canterbury between the 2013/14 and 2015/16 seasons.

Legume seed production

Phil Rolston and Richard Chynoweth, FAR

Trial 1 Alternative legumes

Objectives

1. To provide seed producers with information on issues and relative seed yields of a range of annual and perennial legumes.
2. To evaluate time of flowering of various legume species with potential to provide early season pollen and nectar for honey bees.

Treatments

The trial will evaluate annual clovers (7 species) and perennial legumes (6 species).

Table 1. List of legumes in trial.

Treatment	Species	Row spacing (cm)
1	Gland clover	15
2	Persian clover	15
3	Balansa clover	15
4	Subterranean clover	15
5	Crimson clover	15
6	Arrowleaf clover	30
7	Vetch (*V. villosa*)	30
8	Sulla	30
9	White clover	30
10	*Lotus pedunculatus*	30
11	Lucerne	30
12	Red clover	30
13	Caucasian clover	30

Trial 2 Gland clover

Two trials investigating management of gland clover have been established to investigate the role of a companion grasses during establishment and herbicide options.

Treatments

Table 2. Companion species in gland clover trial.

Treatment	Companion species	Sowing rate (kg/ha)
1	-	-
2	Italian ryegrass	3
3	Italian ryegrass	6
4	Perennial ryegrass	3
5	Perennial ryegrass	6
6	Oats	30

Table 3. Herbicide treatments in gland clover trial.

Trt	T1 21.3.17	T2 27.4.17	T3 24.5.17	T4 4.9.17
1	Stomp® Xtra 3.5 l/ha		Preside™ 65 g/ha	
2		Preside™ 65g/ha		
3			MCPB 3 L/ha	
4			Preside™ 65 g/ha	MCPA 100ml/ha + MCPB 2.92L/ha
5			Jaguar® 1.5 L/ha	
6			Preside™ 65 g/ha	Spinnaker 400 ml/ha
7			Quantum® 200 ml/ha	
8				Arrow® 0.5 L/ha

Trial 3 Desiccation of white clover

The trial was established in autumn of 2016 to investigate desiccation of white clover to aid harvesting. Treatments were based on a pre-desiccation treatment of MCPA and Reglone® was used as the main desiccant.

The herbicides Buster®, Roundup® and Versatill™ were used in addition to an attempt to provide alternative options for seasons when white clover is hard to dry down. Many treatments produced similar seed yields but there was an advantage to including MCPA as a pre-treatment seven days prior to Reglone® (trt 1 vs. trt 2). Autumn and winter regrowth was slow on treatments where Versatill™ and Buster® were applied but plants were not completely removed.

Table 4. Herbicide treatments in white clover desiccation trial.

Treatment	Pre-treatment	Desiccation timing 1	Desiccation timing 2	Seed yield (kg/ha)	Ground cover (%)
	16.2.17	20.2.17	23.2.17		15.9.17
1	nil	nil	Reglone®4 l/ha	630	89
2	MCPA 2 l/ha	--	Reglone®4 l/ha	760	78
3	--	Reglone® 2 l/ha	Reglone®2 l/ha	740	85
4	--	Buster 5 l/ha	Reglone®4 l/ha	780	65
5	MCPA 2 l/ha	Buster 5 l/ha	Reglone®4 l/ha	725	40
6	MCPA 2 l/ha	Buster® 2.5 l/ha + 2 l/ha Reglone®	Reglone®4 l/ha	740	65
7	--	Versatill™ 350 ml/ha	Reglone®4 l/ha	710	8
8	MCPA 2 l/ha	Versatill™ 350 ml/ha	Reglone®4 l/ha	770	13
9	MCPA 2 l/ha	Roundup® 3 l/ha	Reglone®4 l/ha	695	60
10	MCPA 2 l/ha	---	Roundup® 3 l/ha + Reglone®4 l/ha	760	78
11	MCPA 2 l/ha	---	Buster® 5 l/ha+ Reglone®4 l/ha	750	70
12	MCPA 2 l/ha	---	Versatill™ 350 ml/ha+ Reglone®4 l/ha	765	34
			Mean	730	
			LSD $_{0.05}$	88	

Alternative species – crops for the future

Matilda Gunnarsson and Nick Pyke, FAR

Key points

- New Zealand has excellent climate, water, soil and farmers.
- Need to identify and develop new sustainable and profitable crop and food options.
- Crops planted at Chertsey include peas, purple wheat, durum wheat, red lentils, buckwheat and spelt.
- Similar trials also underway at other FAR research sites elsewhere in New Zealand.

New Zealand has a number of advantages in relation to cropping. It is one of the few areas in the world that has water, good quality soil, a temperate climate, highly skilled farmers and political stability. To capitalise on these benefits we need to develop suitable cropping systems, select crops which can be grown profitably and sustainably, develop new business models so farmers have greater ownership of the value chain and ensure we understand future food trends and produce high quality food products that appeal to the consumers.

The *Future Foods Project* addresses these issues and aims to work both from the market back and from what we can grow forward, to develop new profitable crop and food options. Internationally there are huge changes in food trends and significant interest in the future of plants to provide protein for products such as Sunfed, a chicken tasting pea protein or the Impossible Burger. The challenge for plant proteins is to produce a unique product and extract the value for New Zealand. There may also be opportunities for nutritional beverages, novel grains, high value oils and fresh water containing plant exports.

Alternative crop trial at Chertsey

The trial was established using a disc type plot drill sowing 9 rows at 15cm spacing on 20 October.

Treatments	Cultivar	Sowing rate
Peas	Miami	250 kg/ha
Purple wheat	Unknown	220 plants/m2
Durum wheat	Farina	250 plants/m2
Red lentil	Rajah	100 kg/ha
Buckwheat	Unknown	60 kg/ha
Spelt	Unknown	120 kg/ha

Why these crops?

Lentils are leguminous and therefore provide a good crop rotation option to help restore soil fertility. Rajah, planted in this trial, is a New Zealand bred red lentil used for both export and the local split lentil market. Consumption of pulses is increasing in the health conscious and ethical consumer sector. Pulse production is perceived as having a reduced environmental impact and a good option for avoiding ethical issues around animal welfare compared to animal derived protein options.

Specialty wheats are largely used in baked goods and bread in particular. Specialty wheats tend to be older varieties, and are generally perceived by consumers to be more flavoursome and nutritious. Demand for baked goods containing these products is still largely niche, however demand has increased from trend and health conscious consumers. Buckwheat could fall in the same category, as it can be used for gluten-free flour. Buckwheat is also used as a cover crop to increase soil aggregate stability, supress weeds and attract pollinators.

Trials in other locations

This season we also have two sunflower trials, one at our research site at Lincoln and one at Dorie. The trial at Lincoln is a time of sowing trial with two varieties of sunflowers, both with high oleic content for high quality oil extraction. Both varieties are monounsaturated which means that they need to contain more than 85 % oleic acid. These oils are used for frying and margarines due to their long shelf life and high temperature cooking stability. The Dorie trial is a herbicide trial with 10 treatments (7 pre-emergent herbicides and 3 post-emergent herbicides). It has been designed to determine the relative strengths and weaknesses of different herbicides applied at a range of application rates from 2x commercial rates down to 25% doses.

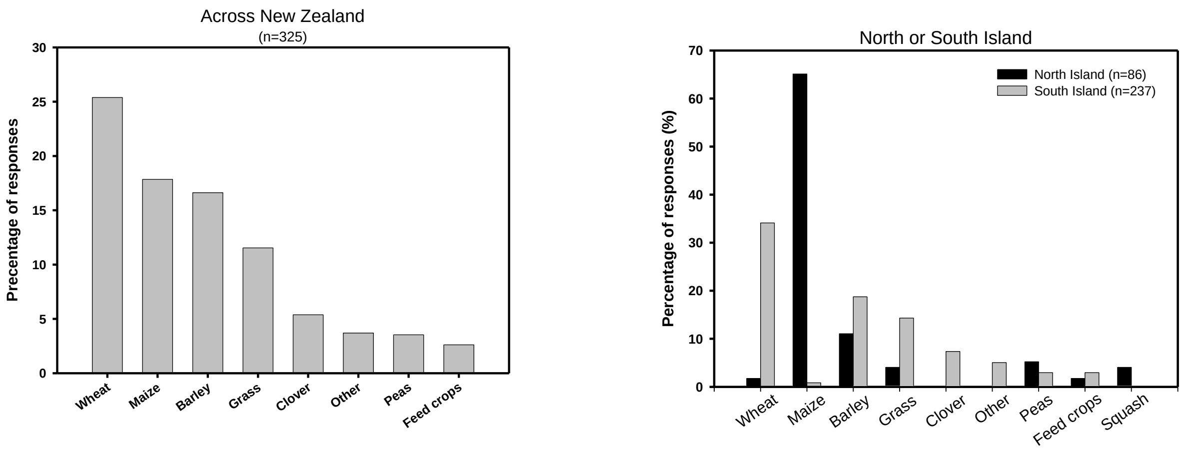
A similar trial as the one at Chertsey is replicated both in the Wairarapa and at FAR's Northern Crop Research Site (NCRS). These trials include a few other species that are suitable for the climate in North Island, such as chickpeas, faba beans, sorghum and naked pumpkin seed.

New Zealand cropping sequences – where have we come from, what's important for the future?

Nick Poole, FAR Australia

The FAR cropping sequence survey was first conducted in 2006 to identify the different rotations being practiced across New Zealand and to pinpoint the main problems associated with those rotations. One of the key questions asked of cropping farmers was "what was the key crop driving the economics of the cropping sequence on your farm". In 2011 and 2016 FAR repeated the survey with similar questions so that it was possible to record the changes that were occurring on New Zealand cropping farms.

At first glance very little appears to have changed over the last decade, since wheat was reported as the key crop driving the economics of cropping sequences in both 2006 and 2016 surveys. On a regional basis wheat was the key crop in South Island and maize the key crop in the North Island. However, with more scrutiny it is clear that there has been change in land use, since the number of growers citing barley as the key crop has declined since 2006, although the crop's importance in North Island remains second only to maize. In addition, in 2016, traditional New Zealand crops, such as white clover, were cited as a less important crops, whilst potatoes, process vegetables and vegetable seed crops had greater influence on the economics of the rotation.

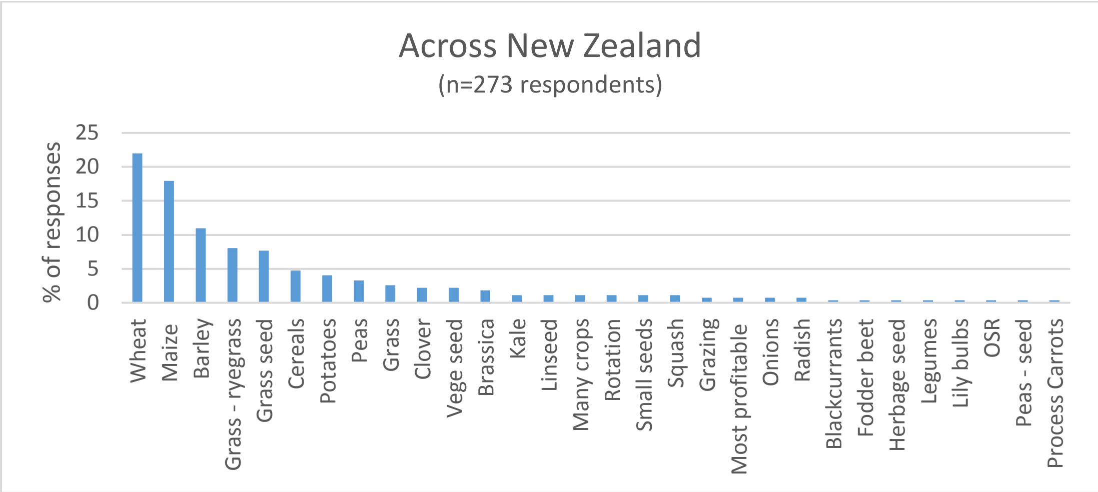


a) **b)**

Figure 1. Key crops driving the economics of cropping sequences a) across all of New Zealand, and b) for North and South Islands separately, as reported by respondents to a FAR survey in 2006. n = number of responses.

Overall, the range of crops reported as key to driving the economics of cropping sequences in the South Island continues to be more varied than in the North Island, a feature probably linked to an increase in irrigation over the last decade. Many higher returning crops, such as vegetable seed and potatoes, are being contracted where irrigation is available.

a)



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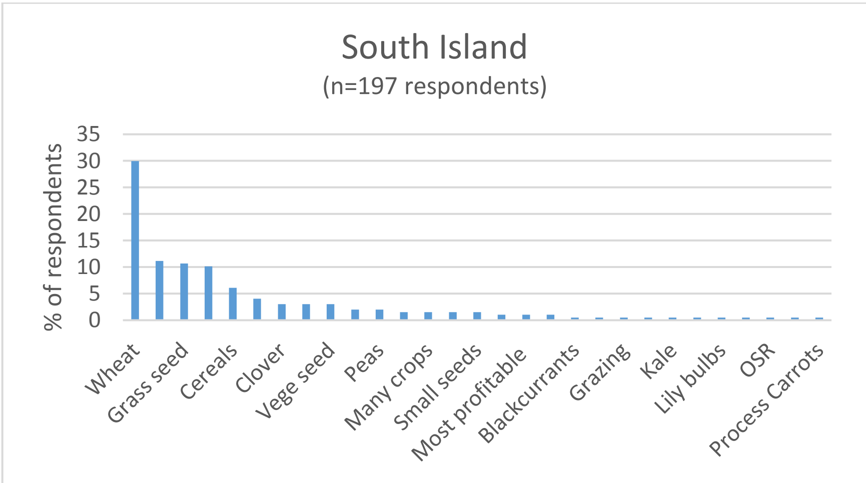

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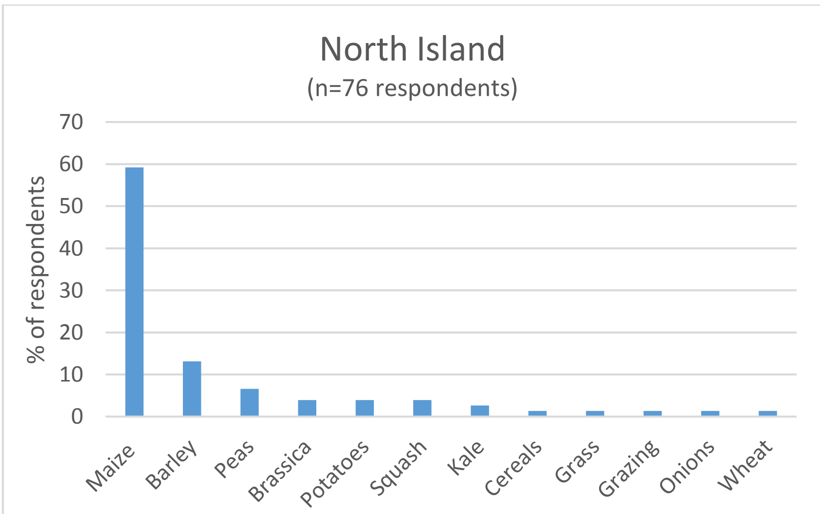


Figure 2. Key crops driving the economics of cropping sequences a) across all of New Zealand b) for South Island and c) North Island, as reported by respondents to a FAR survey conducted in 2016.

What current issues are reflected by these rotations?

The 2016 responses highlighted that the problems faced by growers are almost identical to those reported 10 years ago, with weed issues and crop establishment cited most often. On-going weed issues link with continued dependence on herbicide use and the associated dangers of over use and herbicide resistance.

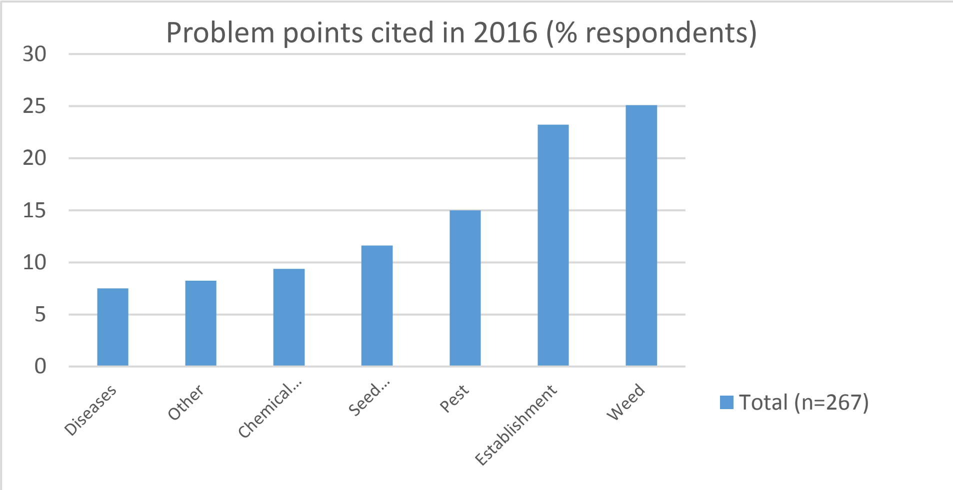


Figure 3. Problem points identified by growers in the FAR 2016 Cropping Sequence Survey.

So where are we heading with our cropping rotations?

Respondents suggested that profitability and the overall outlook for cropping were the main risks to cropping businesses in New Zealand. This was over and above biosecurity and issues such as agrichemical resistance. As such, it is clear that growers will need to continue to pursue a wider range of higher return enterprises in order to maximise margins on cropping farms and compete with other land uses, such as dairy, or alternatively increase productivity in more traditional commodity based rotations. Increased levels of dairy support and more growers citing potatoes, specialist seed and vegetable seeds and process crops are more recent pertinent examples of this shift.

Grass phase

The importance of the grass phase in New Zealand cropping rotations does not appear to have diminished over the last 10 years, although surveys suggest that the length of the grass phase is reducing. Having a profitable grass phase in the rotation still looks to be an important ingredient going forward and one where New Zealand rotations hold an advantage over cropping rotations based purely on a sequence of annual crops. The importance of a "restorative" phase to rebuild organic matter and soil quality cannot be overstated.

Fertility

Going forward, there is likely to be a need to redesign mixed farming enterprises so that the nutrients exported in forage and grain grown for livestock support can be returned to cropping farms (as manures from livestock). Higher fertiliser prices will ultimately drive this change.

The grass phase is clearly a convenient platform for these nutrients to re-enter the cropping rotation. Nutrients could be returned by grazing itself via autumn and winter grazing (although the soil damage caused by cattle in wet winters has to be considered in terms of its long term consequences, particularly on heavier soils) or by the collection and spreading of nutrients from herd homes. It is not sustainable for cropping rotations to continually mine their nutrients and export them to dairy enterprises without those nutrients being returned or replaced from another source. The other rotation change is forage (e.g. fodder beet) and combinable crops being grown on dairy farms in order to utilise nutrient build ups and to prevent leakage of nutrients into the environment (this is already happening to some extent). This should potentially create new models for the relationship between livestock and cropping sectors. Clearly nitrogen fixing crops such as legumes still have a huge role in maintaining fertility within the rotation.

Diversity & Agrichemical resistance

The agrichemical revolution of the last 40 years has enabled growers to practice rotations that are more profitable. For example, the use of grass weed herbicides to control grass weeds in cereals without the need for ploughing or a winter fallow. However, in New Zealand, despite more diverse rotations than those practiced overseas (e.g. Australia and Europe), we are not insulated from agrichemical resistance; our rotations have instead delayed its onset. We now have issues of herbicide and fungicide resistance in broad-acre cropping enterprises in New Zealand. Therefore, increasingly sound principles of crop rotation and the insertion of a pasture/grass phase will be still be necessary to avoid excessive use of insecticides, fungicides and herbicides. The promise of improved genetics, whether it be for control of pathogens (Genetically Modified (GM) solutions) and weeds, or exhibited as improved host plant resistance will be essential to fill these gaps. If not, then intensive cropping sequences dependent on high agrichemical input will increasingly fail. This will continue to place greater emphasis on the need for Integrated Pest Management (IPM) where we use rotations, genetics, cultural control as well as agrichemicals to control the target pest. Crop competition and the use of cover crops will also become more important in order to reduce our dependence on agrichemicals and to protect our soils.

Environmental issues

This paper doesn't intend to cover this aspect in detail, but clearly cutting across all of the above are the increasing demands of environmental compliance on the rotation, which may yet manifest itself in the form of input restrictions if current approaches to nutrient loss are not successful.

Finally, it's important for New Zealand to seek out new opportunities for cropping. The Future Foods project that FAR is involved with is an excellent example of the quest for alternative, higher value, crop options that have the potential to improve cropping margins as well as further diversity of crop options.

Reducing nitrous oxide emissions from broad-acre crops

Michael Straight, FAR Australia

Key points

- Nitrous oxide (N_2O) is produced by soil microbial activity through denitrification and nitrification processes.
- N_2O emissions are increased in very wet/waterlogged soil conditions and also where high levels of livestock waste are present.
- N_2O emission rates are variable on arable farms depending on soil type, climate and management practices.
- It is important to match up nitrogen (N) application with peak crop demand to increase N efficacy and decrease N losses as N_2O.
- In very wet conditions, the N strategies used to optimise grain yield and quality may not be optimal for reducing N_2O emissions.

Why nitrous oxide emissions are an issue for arable farmers?

Nitrous oxide (N_2O) is an important greenhouse gas due to its high global warming potential (GWP), which means it can trap heat in the atmosphere, contributing to global warming. N_2O emissions from Australian grain cropping systems are highly variable due to the large variations in soil, climate and management practices. FAR research confirms that N_2O emissions from dryland cropping systems in NE Victoria are at the low end of the range for farming in Australia. Research conducted in south eastern Australia looked at strategies to reduce N_2O emissions and therefore improve nitrogen use efficiency in dryland cropping soils.

How is N2O produced in soils?

N_2O is produced by soil microbial activity through denitrification and nitrification processes, and is increased in the presence of nitrogen fertilisers, high levels of organic residues and livestock waste, especially when the soil conditions are anaerobic (void of oxygen) such as occurs with waterlogging. Soils also release dinitrogen (N_2) gas through denitrification, however this is difficult to measure as dinitrogen is naturally occurring in the Earth's atmosphere at relatively high concentrations. In general, the release of N_2 from soil can be 20-30 times greater than nitrogen lost through N_2O, although the exact relationship between the two gases depends on the water content of the soil. This means the total amount of nitrogen lost from soil through gas release could be 20-30 times greater than that measured through N_2O emissions.

Results from FAR research in North Eastern Victoria, Australia

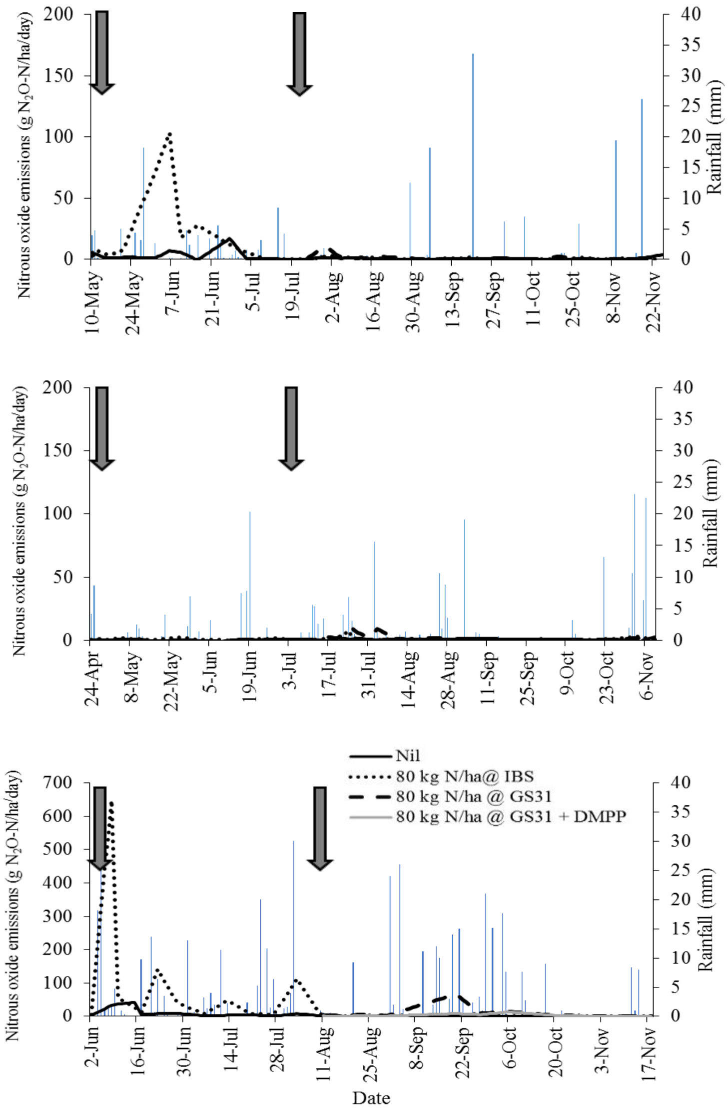


Figure 1. Nitrous oxide emissions for nil, IBS and GS31 nitrogen applications for wheat sown after a legume in 2014 (top), 2015 (mid) and 2016 (bottom) at Yarrawonga.*

**The GS31 + DMPP emissions were also measured in 2016. The grey arrows indicate the date of nitrogen fertiliser application. Please note the change in scale for N_2O emissions in 2016.*

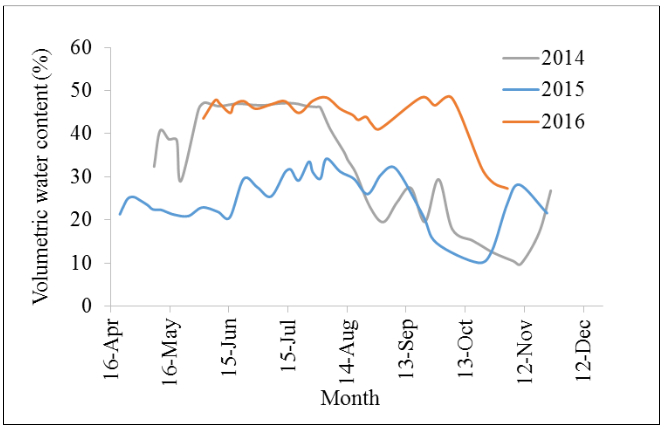


Figure 2. Volumetric water content to a depth of 12cm for the growing season at Yarrawonga from 2014–16.

Table 1. Cumulative N_2O emissions for nil, 80kg N/ha applied IBS or first node (GS31) for wheat following peas or canola at Yarrawonga in 2014–16.

Previous crop	Treatment	Yarrawonga		
		2014	2015	2016
		g N_2O-N/ha/season		
Canola	Nil	212^{b}	109^{c}	1779^{a}
	80kg/ha IBS	1922^{a}	301^{a}	2443^{a}
	80kg/ha @ GS31	340^{b}	197^{b}	2556^{a}
	80kg @ GS31 + DMPP	-	-	1872^{a}
	Mean	82	202	2163
	LSD ($P \leq 0.05$)	1339	50	1189
Peas	Nil	287	78^{b}	809^{b}
	80kg/ha IBS	1686	198^{a}	2738^{a}
	80kg/ha@ GS31	390	151^{ab}	2052^{ab}
	80kg @ GS31 + DMPP	-	-	1135^{b}
	Mean	785	142	2378
	LSD ($P \leq 0.05$)	ns	73	1262

Conclusions

The research highlighted that growers can try to synchronise nitrogen supply with peak crop nitrogen demand to encourage greater fertiliser uptake and potentially reduce N_2O losses. However, while this strategy was beneficial for grain yield and quality, in some seasons it was not optimal for reducing N_2O emissions due to waterlogged conditions.

In the project, delaying nitrogen applications maintained grain yield, while protein was increased compared with incorporation by sowing only applications. The strategy of delaying nitrogen applications allows growers to make fertiliser decisions as the season progresses, with more accurate forecasting and when crop demand for nitrogen is higher (e.g. stem elongation phases). If the forecast is for a wet season, there will be higher potential for nitrogen losses. In this scenario,applying more nitrogen upfront to get the crop through 'wet' periods may be the best strategy in terms of grain yield and quality, when there are limited opportunities to spread fertiliser in season, but may result in elevated N_2O losses.

Reducing nitrous oxide emissions from broad-acre crops

Steve Thomas, Plant & Food Research

Why nitrous oxide emissions are an issue for New Zealand farmers?

Globally, nitrous oxide (N_2O) is a potent greenhouse gas and atmospheric concentrations are increasing. In New Zealand almost all N_2O emissions are emitted directly or indirectly from agricultural soils. New Zealand's current target is to reduce greenhouse gas emissions by 30% below 2005 levels by 2030 (Paris Agreement).

How nitrous oxide is produced in soils?

Nitrous oxide is produced in soils by the biological processes of nitrification and denitrification. Key controls of emissions are the availability of soil inorganic (or mineral) nitrogen and carbon that are substrates for the soil microbes, and soil aeration. Wet, poorly drained soils have poor aeration and tend to have the highest emissions. We tend to think of emissions directly from the paddock but there are also indirect emissions, offsite emissions from nitrate leaching and ammonia.

Factors that affect emissions in broad-acre cropping

Management	↑ or ↓ N_2O	Issue	Mitigation Strategy/options
Fertilisation events	↑ ↑	Increases soil inorganic N Urea volatilisation (indirect emission)	Minimise excess inorganic N • Match fertiliser N with plant demand • Slow release fertilisers • Avoid large applications • Avoid applying to wet soils or before large rainfalls Wash in urea with small volumes of rain/irrigation
Cultivation	↓ ↑	Increases aeration of <u>degraded</u> soils Increases mineralised N	Minimise soil disturbance to reduce mineralisation
Fallowing & spraying off	↑	Increases mineralised N	Minimise period of fallow
Residue incorporation	↑ ↓	Increases mineralised N Increases soil C	Account for N in residues in nutrient budgets
Machinery traffic	↑	Compacts soil and reduces aeration	Avoid driving on wet soils Minimise passes Minimise the compacted area
Irrigation	↑	<u>Excess</u> increase soil wetness & reduces aeration. Drainage	Allow soil water deficits to build where possible - maintain good

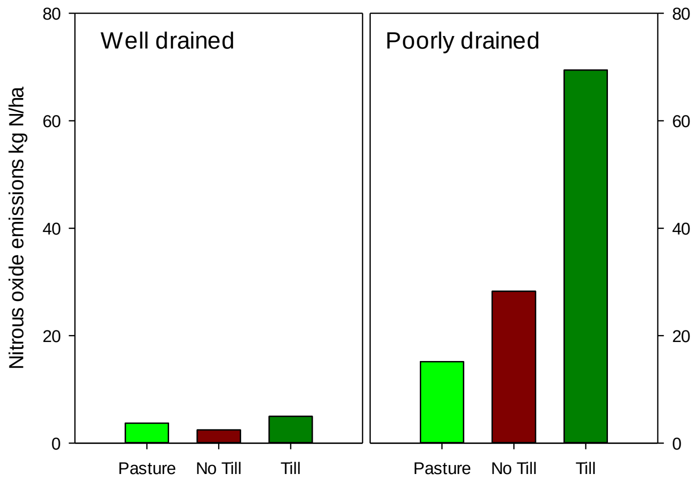
		contributes to indirect emissions	aeration and reduce risk of leaching losses
Animal grazing	↑ ↑	Increases soil inorganic N (excreta) Compacts soils and reduces aeration	Avoid grazing wet soils Minimise fallow periods Cut and carry Manage effluent
Drainage	↓	Increases aeration	Improve aeration and drainage of poorly drained soils

New Zealand examples of nitrous oxide losses

Grazing, tillage to establish forage crops and soil drainage affect N_2O emission.

Wetter, poorly drained soils emit more N_2O than well drained soils under same management.

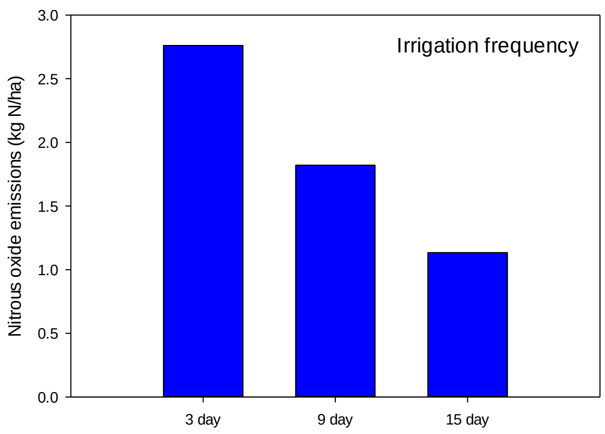
Cultivation increases the risk of animal compaction and greater emissions.



Irrigation frequency can increase N_2O emissions:

Wetter soils produce greater emissions.

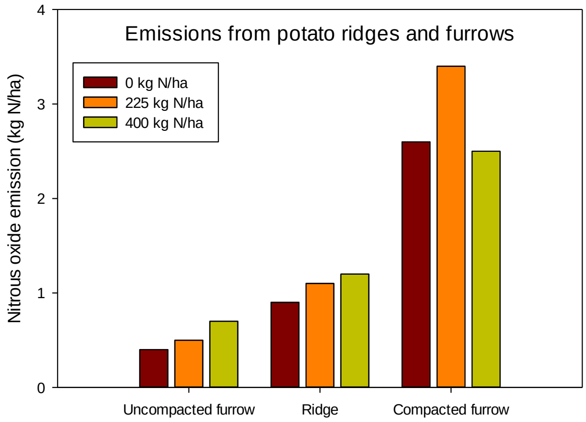
Most emitted from a soil irrigated every 3 days.



N_2O emissions from compacted (wheeled) furrow > fertilised ridge > uncompacted furrow.

Greatest N_2O emissions from compacted furrows, least from uncompacted furrows.

Well–aerated, fertilised ridges had low emissions.



Conclusion

Management strategies to reduce N_2O emissions are nearly always ones that are recommended for good soil, water and crop management. Aim for efficient nitrogen and water use, and avoid compaction.

Tillage and crop rotation – impacts on soil quality

Abie Horrocks, FAR and Craig Tregurtha, Plant & Food Research

Key points

- Carbon (C) is a key determinant of soil health and the intensity of cultivation effects how it is distributed down the profile.
- No-tillage has resulted in a build-up of C in the top 0-15 cm. This has led to improved soil structure and water storage in this highly active zone of the soil profile.
- Time is an important factor, as the first five years of measurements from the FAR cultivation trial produced relatively small differences between cultivation treatments, whereas the 2015 and 2017 data are showing stronger improvements to soil quality with no-tillage. Cumulatively, yields are also greater with no-tillage, especially in the dryland plots.

FAR's Chertsey Cultivation Trial was established in 2003 to identify various aspects of crop production under different cultivation intensities. The field trial is a split plot design with two factors: irrigation (irrigated and dryland) and tillage (a mixture of primary and secondary cultivation combinations). The trial has four reps that have six plots with six tillage treatments randomly allocated. In 2017, tillage treatments have been combined so that rather than having two representative scenarios for plough, non-inversion and no-tillage, there is just one (Table 1). This was done to increase replication across the irrigated and dryland blocks and to update the tillage treatments to be more representative of current practice.

Table 1. New combined treatments, cultivation intensity, cultivation equipment used and soil disturbance ratings (SDR) in 2017 for the FAR long term cultivation trial, Chertsey, Canterbury.

Treatment	Cultivation	Degree of Cultivation	SDR
1	Inversion	Plough + 1 or 2 maxi-till passes + Drilled John Deere 750A double disc	51, 72*
2	Non-inversion	2 Passes Topdown (shallow) + Drilled John Deere 750A double disc	73
3	No-tillage	Drilled John Deere 750A double disc	7

*Two passes of maxi-till in treatment one.

Carbon provides an important food source for soil organisms and is the building block for all cell material. It is a key determinant of soil health because it regulates most soil biological, chemical and physical processes. The benefits of increasing organic matter (carbon) to soil function include preservation of soil structure, improved aeration, water infiltration and water storage, and encouragement of earthworms and other soil fauna.

There are many ways to build and maintain soil C such as with crop roots and residue, cover crops, mulch, livestock and compost.

Minimising cultivation can reduce C loss as soil disturbance releases C to the atmosphere. Often the primary change that comes from a shift in cultivation practice is to do with how the C is distributed down the profile (Figure 1). With inversion tillage there is a greater re-distribution of C down the soil profile (to the depth of ploughing) and with no-tillage there is a build-up of C in the top 0-15 cm (Figure 2). There are functional implications of this re-distribution of C down the profile. Soil quality indicators (soil compaction, soil structure, soil water storage, chemical fertility, total nitrogen (N) and C and biological health) have been monitored at various points throughout the cultivation trial by Plant & Food Research. Soil quality measurements taken in 2017 show some significant benefits occurring from prolonged implementation of reduced tillage, with the no-tillage plots typically having improved soil structure (Figure 3), greater water storage ability (Figure 4) and higher organic matter content (in the 0-15 cm depth) when compared with the inversion and non-inversion treatments.

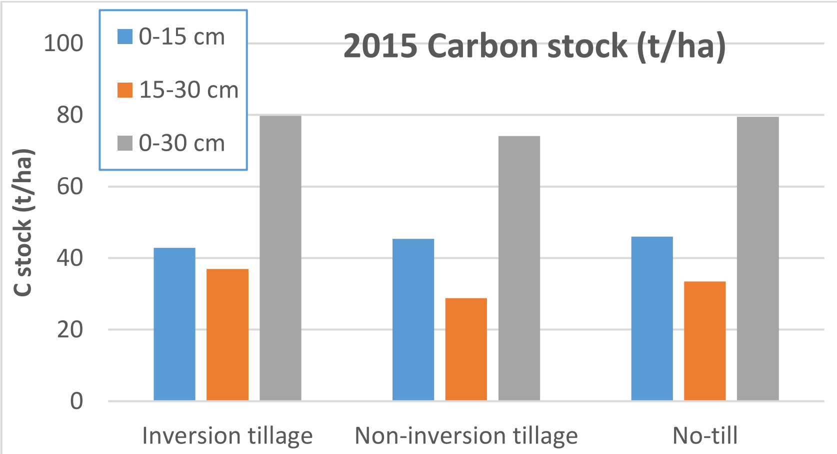


Figure 1. 0-15 cm, 15-30 cm and 0-30 cm carbon stocks (t/ha) in the FAR long term cultivation trial, Chertsey, 2015 for the Inversion, Non-inversion and No-tillage treatments.

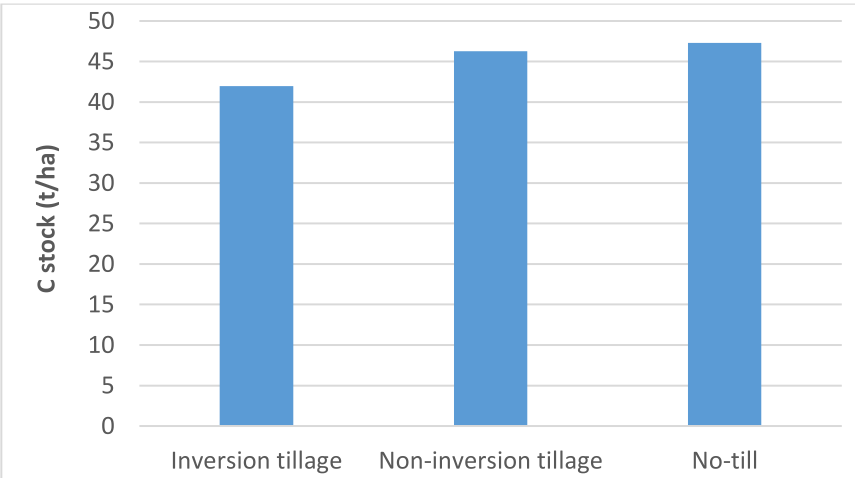


Figure 2. 0-15 cm carbon stock (t/ha) in the FAR long term cultivation trial, Chertsey, 2017 for the Inversion, Non-inversion and No-tillage treatments.

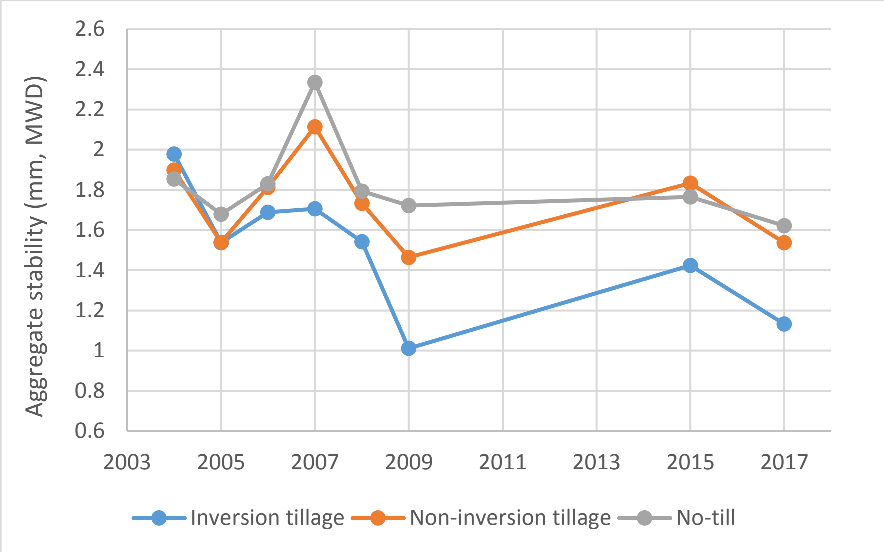


Figure 3. Soil aggregate stability (mm, MWD) from the FAR long term cultivation trial, Chertsey, 2004-17 for the Inversion, Non-inversion and No-tillage treatments.

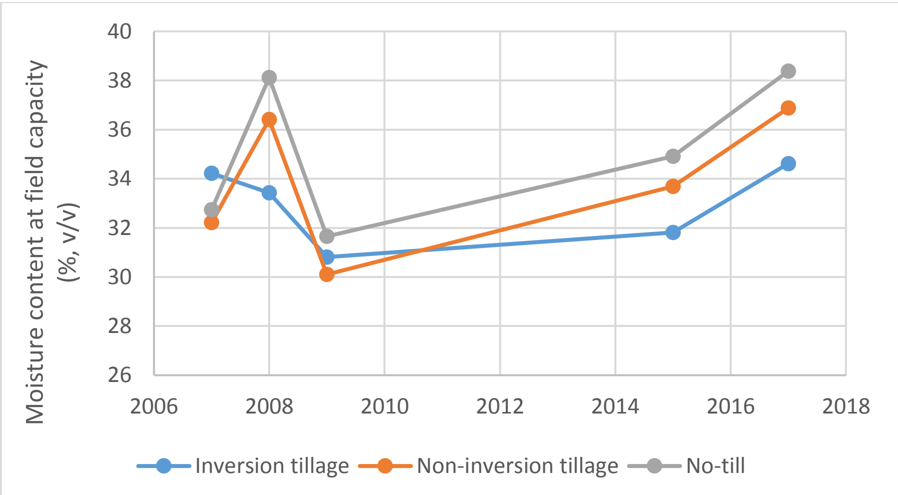


Figure 4. Moisture content at field capacity (%, v/v) from the FAR long term cultivation trial, Chertsey, 2007-17 for the Inversion, Non-inversion and No-tillage treatments.

Figure 5 shows the clear difference irrigation makes to yields but also highlights the growing difference tillage can have. Yield responses to a reduction in tillage are more apparent for the dryland system than the irrigated system. This is because the benefits of greater water holding capacity with reduced tillage are more relevant in a dryland situation where water is limiting.

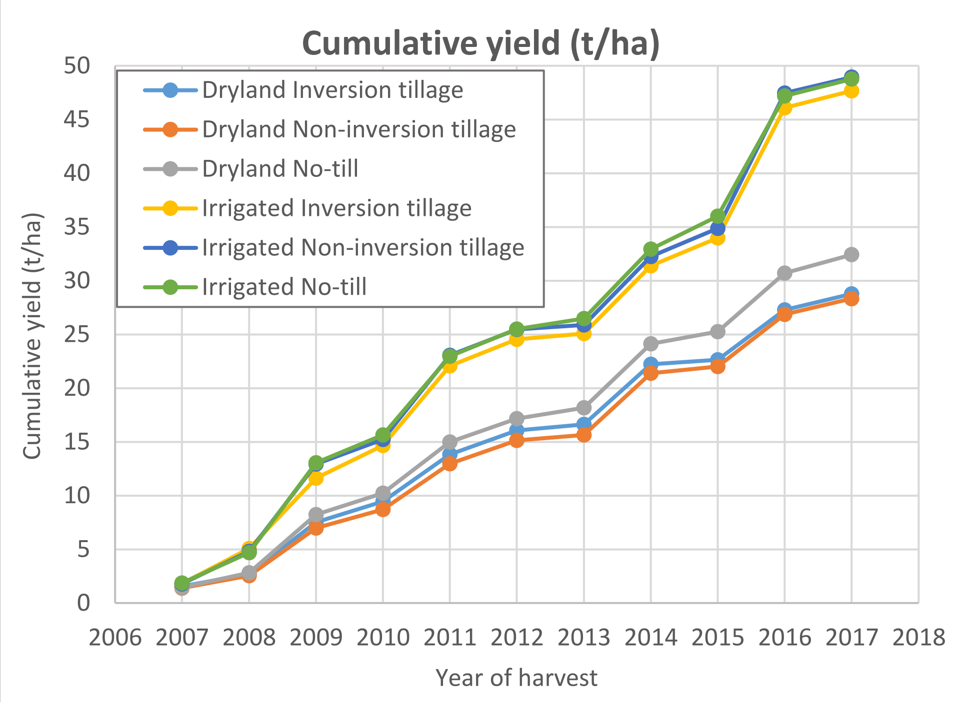


Figure 5. Dryland and irrigated cumulative yields (t/ha), from the FAR long term cultivation trial, Chertsey, 2007-2017 for Inversion, Non-inversion and No-tillage treatments (dryland and irrigated).

Soil physical parameters respond to many things. In general, they will decline with cultivation and under forces such as heavy machinery and grazing (especially when the soil is wet). They decline with harvesting when the crop is underground (such as potatoes) or harvested in wet conditions due to a short time frame (e.g. fresh peas). So it is important to minimise these soil quality losses as there is no quick fix to improve soil quality. The absolute best thing for soil, in terms of improving the physical health is to include a well-managed pasture in the rotation as this will return high levels of quality organic matter to the soil. Table 2 highlights organic matter returns from pasture in comparison to other crops. The FAR cultivation trial demonstrates some of the functional benefits that can be gained by reducing tillage and building up C in the top 15 cm.

Table 2. Organic matter returns from a selection of crops.
Source: McLaren and Cameron, 1996.

Crop	Organic matter added to top 20cm of soil (kg/ha)
Potatoes	250
Spring cereals	1300
Autumn cereals	2200
1 year pasture	4000-5000
3 years pasture	6000-8500

Grain storage techniques to protect grain quality – what can we learn from the Australian experience?

Peter Botta, PCB Consulting and Joanne Drummond, FAR

Key points

- Grain is often stored for extended periods. Ensure you plan and can match your grain storage goals with a system that is effective and supports best practice.
- Successful grain storage relies on an integrated quality management approach, combining grain hygiene, monitoring, correct chemical use and, where applicable, aeration.
- Know the enemy, insects are different and do different things.
- Once grain is in on-farm storage, the system becomes an integral part of the supply and food chain.
- Understand the difference between protectants and knockdowns.
- Always consider the future. It is likely that the New Zealand storage system will need to integrate fumigation using quality gas-tight sealable silos.
- Preserving access to phosphine as an insect control tool, through correct use in gas-tight sealed storages, is critical to maintaining grain quality during long-term storage.

On-farm storage can be an integral part of the farm business, so ensuring it works efficiently and delivers the outcomes you and the market need and want should be the goal of the storage system. This presentation will outline some experiences from on-farm grain storage systems in Australia, noting what has worked and things to consider when storing grain.

The key to success is knowing the target outcome for the grain and to match the storage system to that end. For example, generally it is difficult to store grain long-term in a system intended for short-term storage. The other major consideration is that increasing levels of resistance to the contact treatments used in unsealed storage are making insect control more difficult. Investing in gas-tight sealed storage or having at least a proportion of storage gas-tight sealed enables successful fumigation to kill insects.

Effective grain storage is essentially about managing time, which in turn is about being able to kill insects when the need arises and manage grain quality during the storage period.

Growers will typically use and have a variety of storages at their disposal. While each should work well for their intended purpose, it is worth considering the pros and cons of each; particularly in regard to the ease of insect and quality control for the expected period of storage.

Plan for success

Having a plan is essential to ensure successful grain storage. Know where your grain is, determine suitable protection periods for specific storages, record treatments, determine quality specifications and know when to check grain.

Often a storage site will increase in size over time and planning for expansion is essential (for example, to ensure access to power for future aeration). Also, ensure any storage facility is easy to access and use. When considering new storages plan for the end goal.

Thinking about storage periods

For short-term storage, some Australian growers use “ground dumping” and silo bags. Ground dumped grain should be moved or used within six weeks if possible. Silo bags offer better protection from the elements and are particularly good for managing harvest pressure.

For medium-term storage growers can use unsealed silos, sheds, silo bags and gas-tight sealed silos. The longer the storage period required, the greater the potential for infestation. It is difficult to control insects in sheds (even when grain is treated) and the options for killing insects if grain becomes infested are limited. Silo bags are typically not treated and require nil insect levels when loaded.

Although we presume there are no insects in grain being loaded into storage, we generally treat the grain using protectants, or fumigate in gas-tight sealed storage. When using protectants always read and follow label directions, calibrate, mix and apply chemicals correctly and always wear the recommended safety gear. Aeration is increasingly common and can help manage insects and quality in unsealed storage. In many cases, well managed aeration combined with good grain hygiene, can deliver grain with no or minimal infestation.

Know the enemy: Grain insects are either primary or secondary pests.

Primary pests (below) attack and develop in the grain, leaving a floury residue and eaten out grains. The lesser grain borer and weevils are primary pests.

Secondary pests (below) eat grain dust and residues. They are generally scavengers and do not typically attack whole grains. The flour beetles, saw toothed grain beetle, rusty grain beetle and psocids are secondary pests.

Different insects prefer different conditions, can breed at lower temperatures and are potentially resistant to treatments. In Australia, the lesser grain borer is resistant to all organophosphate chemicals (i.e. Actellic®, fentrothion and Reldan™), so treatment combinations are necessary for control. If you detect primary pests in your grain, intervene quickly. If they are secondary pests there is time to act, as in small numbers secondary pests do little, if any, damage and the grain may be used before any intervention is necessary.

Keep it clean

Whatever the system, follow the basic principles. Most important is excellent grain hygiene - prevention is better than cure. Clean up any grain spills immediately, wherever they may be, but particularly around the storage area. To help this process, spray out or remove any weeds around the storage area. Silos mounted on a slab are easier to clean and keep clean.

Ensure all harvesting, handling and storage equipment is clean and treated with a structural treatment. Inert dusts (for example, Dryacide®) can be used to treat the header, storage and handling equipment for residual control. Always read and follow label directions.

Protectants vs knockdown treatments

Grain storage protectant chemicals are treatments which are applied to the grain stream up an auger when filling a silo or shed. These are designed to protect grain from infestation if or when insects crawl or fly into the storage, or adults emerge in the grain from immature stages. ***They are not designed to kill an existing insect infestation.*** They will give residual control, i.e. protect the grain for a period of time (which will be affected by temperature and moisture).

Currently, in New Zealand, the main protectant being used is Actellic®. If what we have experienced in Australia with resistance development is occurring in New Zealand, then monitoring for resistance would be beneficial. In Australia it is necessary to use a combination of protectants to manage resistance.

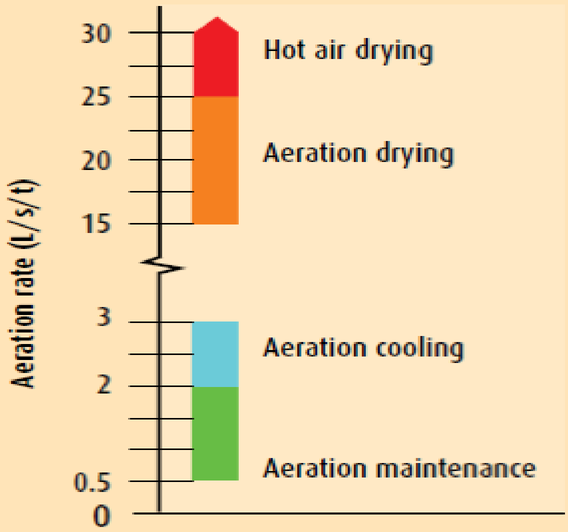
Knockdown treatments are designed to kill an infestation but do not provide any residual control (protection), i.e. fumigants. Fumigants are essentially a knockdown but as a gas, they must be used in gas-tight sealed storage. They include phosphine, sulfuryl fluoride (ProFume®) and controlled atmospheres (nitrogen gas).

Increasingly, growers are storing grain for up to 12 months. To do this the storage system needs to be able to kill insects effectively and maintain grain quality. Gas-tight sealed and aerated storage is the best way to do this. Fumigating the grain kills any insects present and the aeration maintains grain quality.

In a gas-tight sealed silo grain can be fumigated effectively providing quick, inexpensive and long-lasting insect control. Market flexibility is greatly enhanced because grain is stored residue-free. When considering new storage, consider gas-tight sealed storage as an option. Like any piece of equipment on the farm, gas-tight sealed silos need to be well maintained to work efficiently. Check seals before filling and replace if worn or damaged. Always pressure test the silo to ensure it is sealed.

If grain is found to be infested, the only way to eradicate insects is by fumigation. Protectants (i.e. Actellic®) are not designed to kill an infestation.

FIGURE 1 Aeration rates for grain drying and cooling



Source: Kondinin Group

Maintaining quality

High moisture and temperature can affect grain in many ways - insect activity increases, spoilage can occur due to moulds and fungi, and seed viability can be affected. Always aim to store grain at a moisture content of 12% and at 25° C or less. Harvest temperatures in Australia are often 30° C or higher and during summer, temperatures in silos can exceed 40° C. This makes keeping grain cool a challenge.

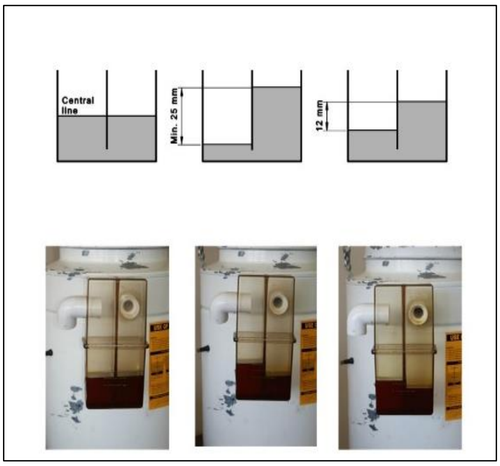
When harvesting, target cool grain to be stored on-farm. Installing an aeration system will further assist in cooling grain. Aeration works best when used in conjunction with an automatic controller.

What should you consider now…

If market requirements and resistance development trend similarly in New Zealand as they have and continue to do in Australia, grain protectant usage will decline and the requirement for pesticide residue-free (PRF) grain will increase. This in turn will increase the use of fumigants and controlled atmospheres.

This will require some gas-tight sealed storage which meets a standard pressure test. To be confident that any new storage is gas-tight, check that it meets Australian Standard AS 2628 - 2010. It is also important that new storage can meet this standard for the expected life of the storage (provided it is maintained correctly). Silos that lose their gas-tightness because of structural failure rather than lack of maintenance are not what you want. Always apply the same decision making principles when purchasing silos and storage equipment as you would any other piece of machinery, it must be fit for purpose.

Images below: A sealed, gas tight silo and the standard pressure test, to ensure the silo is gas-tight and will fumigate effectively.



In most cases it would be impractical to replace all storage with new sealed storage. Where storage is to be increased, good quality gas-tight sealed storage should be purchased. Existing unsealed storage can be fitted with aeration, grain fumigated in sealed storage can be transferred to aerated storage, monitored and confidently stored until needed.

Keep the market in mind

Above all, work with grain end users to ensure any delivered grain meets the receiver's expectations. When the decision is made to store on-farm the system becomes a part of the supply chain and growers need to manage the grain understanding it is a food product in most cases. A system that allows easy grain storage, while maintaining quality will ensure growers can deliver grain that meets market expectations.

For further grain storage information go to www.storedgrain.com.au

Or contact: Peter Botta PCB Consulting, Phone +61 417 501 890, pbotta@bigpond.com

Making Money from Precision Agriculture

Allister Holmes, FAR

Key points

- Yield monitor data can inform future crop management decisions, resulting in increased average Gross Margins.
- Aerial imagery can be valuable to pick up large scale trends.
- Using variable rate seeding to plant according to paddock management zones can decrease the cost of seed in poor performing areas without reducing total crop yield.
- Targeting lime applications to specific areas of a paddock can decrease total cost of lime application.

Yield monitors for potatoes

A commercial crop of processing potatoes was grown in irrigated paddock, then harvested with a Grimme potato harvester with a yield monitor installed. Yield differences were observed as shown in Figure 1. From the yield data, geospatial gross margin maps can be generated, as shown in Figure 2.

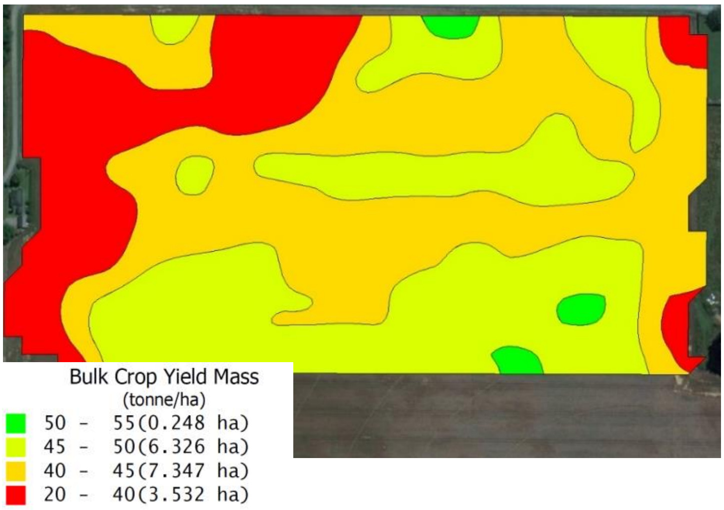


Figure 1. Geospatial potato yield in sample paddock.

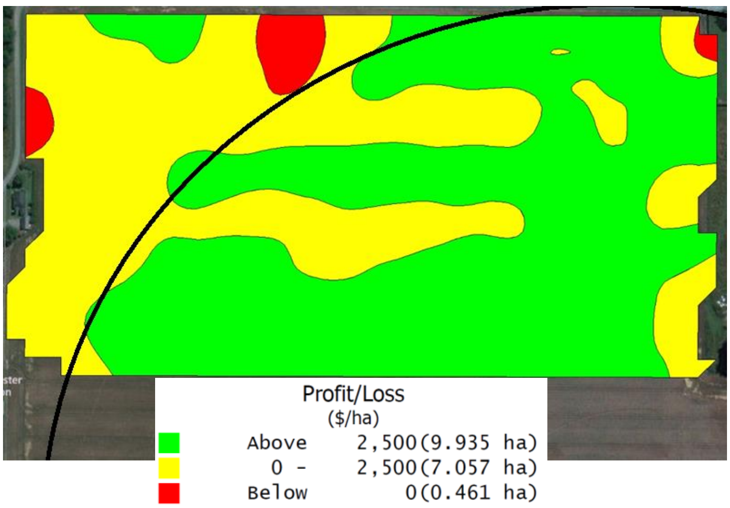


Figure 2. Geospatial Gross Margin yield in sample paddock. Black line shows extent of centre pivot irrigator.

The black curve is the extent of the centre-pivot irrigator, showing the management induced variability from the effect of the area outside the pivot irrigator, which was irrigated using surface pipes and roto-rainers. Based on this information, the grower has decided to grow a crop that is less dependent on irrigation in the portion of the paddock outside the centre pivot irrigator. If the area outside the centre pivot irrigator had not been grown in potatoes the Gross Margin for the paddock would have increased by $440/ha.

UAV images for potatoes
From the ground, little variation could be seen in the potato crop. However, data from a 40 minute unmanned aerial vehicle (UAV flight), showed striping of the crop (Figure 3), which was identified as being caused by overlap from the fertiliser spreader. This has now been remedied. Note also the old stream bed towards the bottom of the image.

Figure 3. Image captured from UAV. Processed using KORE image analysis system.

Managing yield variability using variable rate seeding in maize
A seed rate trial was established at the Northern Crop Research Site (NCRS), to investigate the effect of different planting populations in the different management zones of the paddock. Four replicated strips planted at 75, 90 and 105 thousand seeds per hectare were established.

Management zones were determined by analysing yield data files from the combine harvester from previous harvests and for spatial trends across the paddock, and temporal (time) variability over the different years. From this data, we determined a Management Zone map, and then a proposed variable rate seeding (VRS) prescription, as shown in Figure 4. This VRS prescription was used to establish a trial comparing VRS with fixed rate planting.

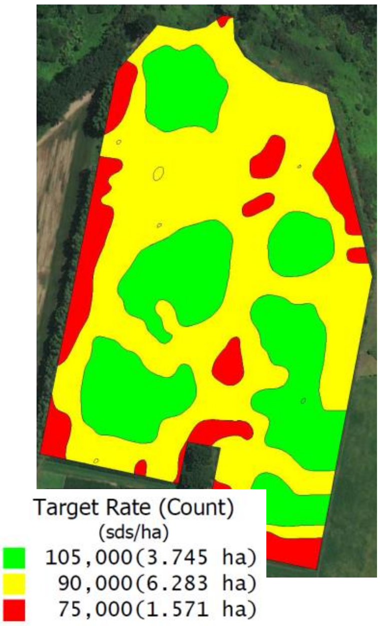


Figure 4
Variable rate seeding prescription for maize planting 2016.

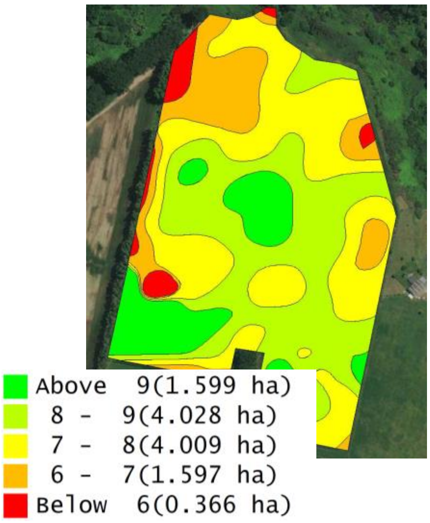


Figure 5
Maize grain yield over a paddock in 2017 (t/ha @ 14% DM).

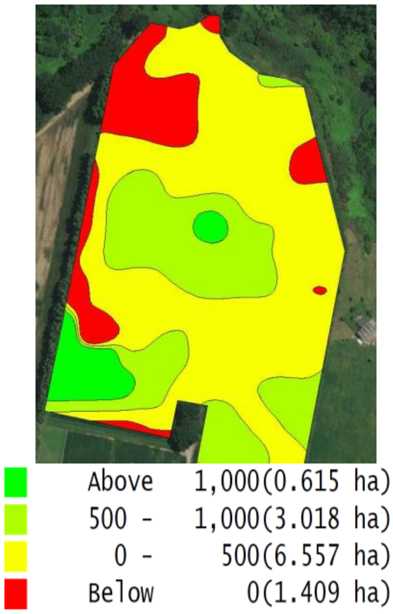


Figure 6
Calculated gross margin for maize grain crop at NCRS, 2017 ($/ha).

Maize harvest results

The maize grain crop was harvested and yield monitor data was recorded and analysed for each of the different management zones and seed planting rates. The average grain yield was 8.0 t/ha. Geospatial variation across the paddock is shown in Figure 5. From this data, we calculated geospatial gross margin (Figure 6). The average gross margin for the paddock was $344/ha.

Using the management zone map, we were able to calculate what the yield and gross margin would have been for the different management zones if we had planted using variable rate seeding. These results show no significant difference between yield and gross margin from the standard and variable rate seeding (Table 1).

Table 1. Seeding rate, yield and gross margin calculated from VRS and standard seed rates.

	Average seed rate (000/hectare)	Yield (t/ha @ 14% moisture)	Gross margin ($/hectare)
Fixed seed rate	100.1	8.1	$417
Variable seed rate	96.0	8.1	$453

If the entire paddock had been planted at 90,000 seeds per hectare, the total 11.6 ha paddock gross margin would be $4,837. If planted using variable rate seeding, the paddock gross margin would be $5,255, an increase of $36 per hectare over the constant seed rate.

Variable rate lime spreading

A sample 4 hectare paddock had geospatial variation in soil pH measured, as shown in Figure 7. The average paddock pH was 5.2, and based on that pH, lime would be applied at 5 t/ha, or a total of 20 t/ha across the whole paddock.

If lime is applied according to variations in soil pH, a total of 14.7 tonnes is applied over the paddock, with rates ranging from 0 to 6 t/ha.

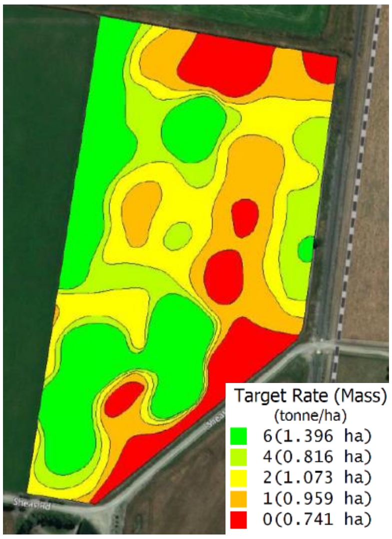


Figure 7. Target rate of lime to be applied based on soil pH variation measured in paddock.

Using VRL saves 5.3 tonnes of lime, and also ensures lime is not applied to areas of the paddock where it is not needed. With the cost of lime applied to the paddock approximately $50/tonne, this represents a saving of approximately $65/ha.

Environmental update for cropping – look how far we have come

Diana Mathers, FAR

Farming, with a view on environmental improvement, is a slow, continuous, cyclical process.

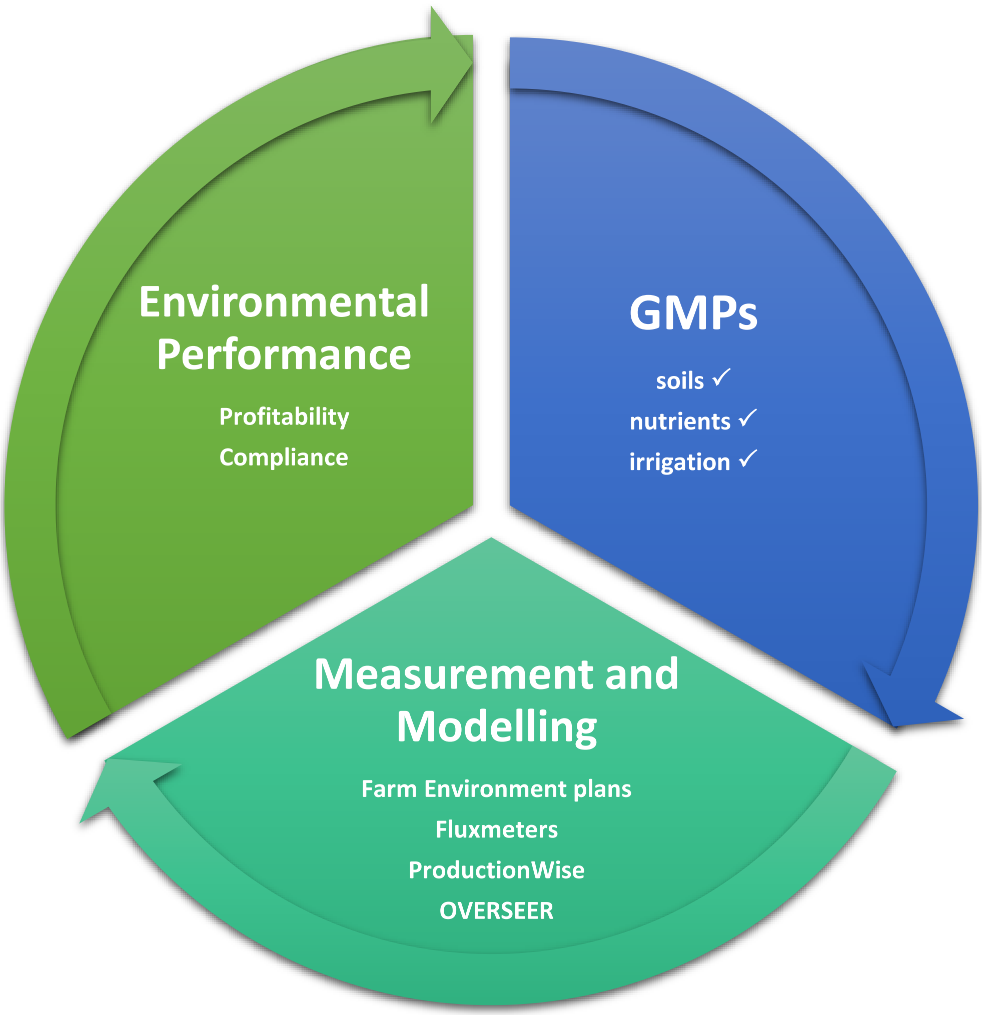
Good management practices for farm management develop in response to technology changes and drivers for improvement often come from beyond the farm gate.

There is an ongoing need to know how high or low the resource losses from the farm are. In the past this was with a view on profitable production. Today, as regional plans are being developed, this is with an eye on consent conditions and compliance to regional rules.

There is no easy way for losses to be measured on every farm, so we rely on farm system models to estimate these losses.

Paperwork, a bugbear of many, provides evidence of your social license to farm. Record keeping and farm environment plans are a way of demonstrating your commitment to managing environmental losses to those beyond your farm gate.

Continuous Cyclical Improvement



Biosecurity - how should we respond to the wake-up calls?

Nick Pyke, FAR and Jim Macartney

Key points

- As an industry we have responded with MPI to a number of incursions to New Zealand in the last few years.
- In future these will be managed under a Government Industry Agreement.
- Farmers need to manage biosecurity at their farm border.
- Herbicide resistant weeds are a high biosecurity risk to farmers.

In the last few years the New Zealand cropping industry has dealt with five new incursions leading to responses involving both government and industry. Black-grass x 2, velvet leaf, pea weevil and red clover casebearer. As part of a collective effort, we also contributed to the successful eradication of the great white butterfly which had established in the Nelson region. This clearly indicates that with the right approach, it is possible to eradicate some pests.

The national border is only one border where we can expect incursions. Every day there are incursions over farm borders throughout the country. Some of these establish as pests, diseases or weeds on the farm, while others may not establish because conditions are not favourable. Many of these incursions are seasonal pests or diseases that are windborne, water splashed or fly across the border. It is very difficult to prevent many of these from crossing your farm border.

The big risks to your farm are weed seeds, pests or diseases that come in with seed, or via machinery, livestock, feed or farm visitors, or from the next door farm. These are risks that you can, and should, do something about.

One of the greatest risks is the potential for the spread of herbicide resistant weeds, of species you already have on farm. Recent visits to Argentina and Australia have highlighted the risk of herbicide resistance and the need for farmers to have a plan to a) prevent herbicide resistance occurring and b) to prevent herbicide resistant species getting on to the farm.

Herbicide resistant ryegrass is causing major problems in both Argentina and Australia - this is in areas where they don't have a major ryegrass seed industry. Herbicide resistant ryegrass is already present in New Zealand and it is essential it doesn't establish in ryegrass seed producing areas and threaten the seed industry. Herbicide resistant ryegrass can be pollen mediated over significant distances - thus it could cross your farm border as pollen, or as seed via machinery or in straw. All farms should have a biosecurity plan which includes strategies for minimising the risk of herbicide resistant ryegrass establishing. A plan for keeping out herbicide resistant ryegrass can also be adapted for use against a number of other weed threats, whether or not they are resistant to herbicides.

Government Industry Agreement (GIA)

Government is changing how it manages biosecurity to be a partnership with industry. Our experience with the recent incursions indicates this approach will achieve the best outcomes. Thus, as an industry, we are working to sign the Government Industry Agreement as soon as possible. However, as an industry we differ from all other agricultural sectors in that we import grain, seed and feed that are threats to our farms and that these often get sown on or delivered directly to farms. We also grow over forty crop species and, for many of these, we have limited information on the risk of new pests and diseases. Our risks are different to other sectors which don't import the product they are producing and it is important this is recognised in any agreement.

As an industry we have had our wake up calls - we have been very lucky that eradication of some incursions is possible. We cannot afford further incursions across our national border and we need to minimise any incursions across individual farm borders.

Health and safety

We trust that you will enjoy your day with us at ARIA; to assist us in ensuring your health and safety whilst on the property we ask that you both read and follow this information notice.

- All visitors are requested to follow instructions from FAR staff at all times.
- All visitors to the site are requested to stay within the public areas and not to cross into any roped off area.
- A hazard list is on display in the main marquee. Please read it and notify a FAR staff member if you have any concerns about one of the hazards listed, or if you see anything else that concerns you.

First aid

We have a number of First Aiders on site. Should you require any assistance, please ask a member of FAR staff. First aid kits are in the main marquee.

Rubbish

Rubbish bins are available for your use; we ask that you dispose of all rubbish considerately.

Vehicles

Vehicles will not be permitted outside of the designated car parking area.

Smoking

No smoking permitted inside any marquee.

Foundation for Arable Research
PO Box 23133, Hornby
Christchurch 8441

Tel: 03 345 5783
Fax: 03 341 7061
Email: far@far.org.nz
Web: www.far.org.nz