FOUNDATION FOR ARABLE RESEARCH

FAR®

Arable Research in Action

Wednesday 29 November 2023

FAR Arable Research Site

Chertsey

9:00am-3:00pm

ARIA

Arable Research In Action 2023

ARIA
Arable Research In Action 2023

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.

On behalf of the Foundation for Arable Research, welcome to ARIA: Arable Research in Action, 2023.

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. Each talk is around 20 minutes long and will be followed by time for questions and discussion. There will also be the chance to talk to speakers at lunch time and at the end of the day.

Lunch

Lunch will be available from the large marquee after the morning presentations finish at 1.00pm

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
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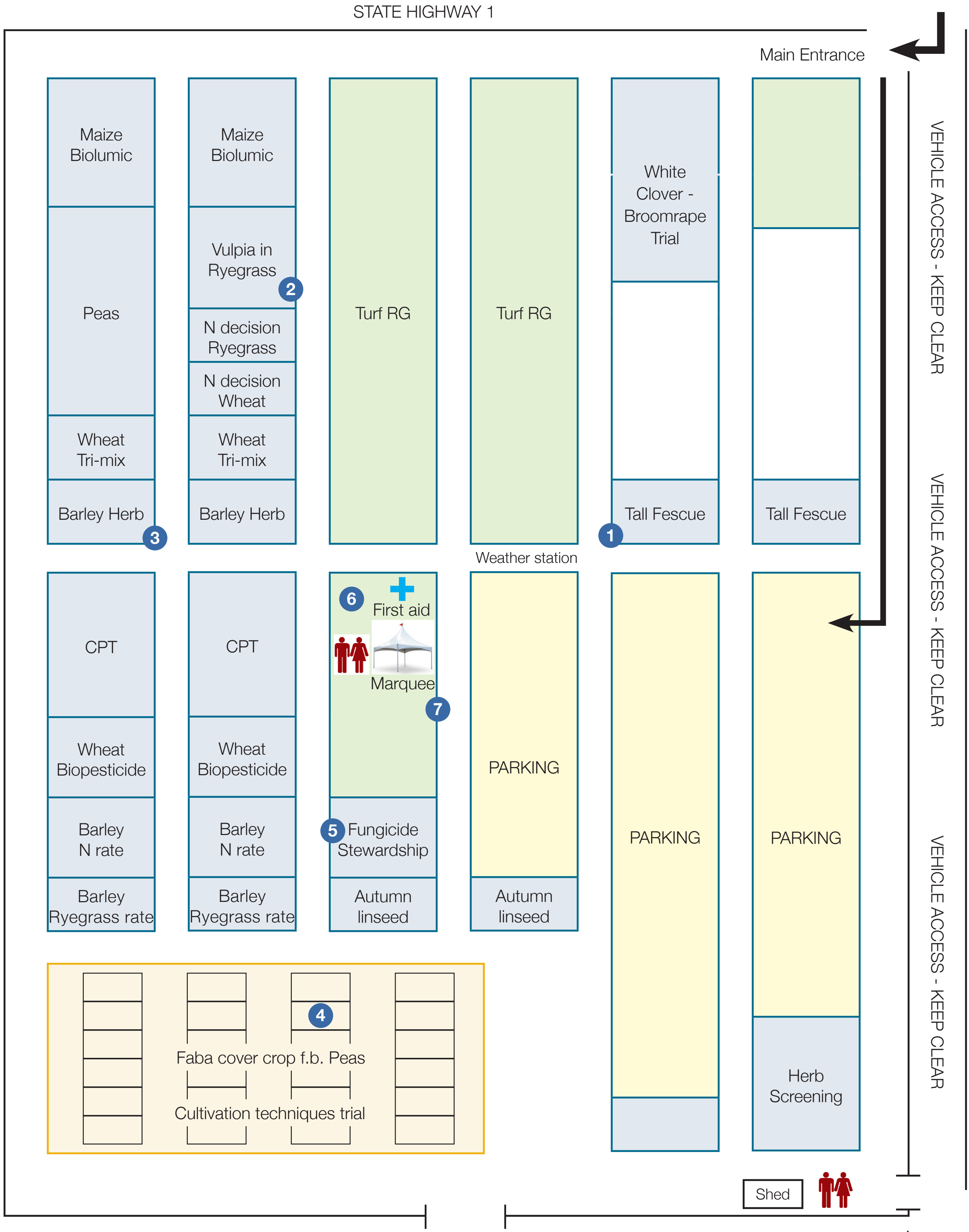
Site plan



Programme

1. **Managing key weeds in ryegrass and clover seed crops** - *Sean Weith, FAR & Nick Davis, AgResearch*
2. **Autumn management of tall fescue and other multi-year seed crops** - *Richard Chynoweth & Chris Smith; FAR*
3. **Crop competition to manage weeds** - *Matilda Gunnarsson, FAR & Pieter-Willem Hendriks, Lincoln University*
4. **Extending the value of ryegrass seed crops** - *Abie Horrocks, FAR*
5. **Fungicide stewardship: learning from the past to protect our future** - *Jo Drummond, FAR & guests*
6. **Transitioning to more resilient arable farming in the UK** - *Rob Waterston, farmer, England*
7. **Harvest loss measurements: the results of recent Australian studies** - *Chris Smith, FAR & Primary Sales Australia*

9.00	9.10	9.40	10.10	10.40	11.15	11.45	12.20	1.00	1.45	2.15
Welcome	1		1	Morning tea in marquee				Lunch in marquee		Conclusion
		2			2					
			3			3				
	4				4					
		5				5				
							6			
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Managing key weeds in ryegrass and clover seed crops

Sean Weith, Matilda Gunnarsson (FAR) and Nicholas Davies (AgResearch)

Key points: Vulpia hairgrass

- Vulpia hairgrass is a common and problematic grass weed in ryegrass seed crops.
- Treatments applied prior to ryegrass emergence achieved the best Vulpia hairgrass control.
- Treatments containing Nortron® applied at pre-emergence of grass weeds, or Prominent® applied at post emergence of the ryegrass, generally achieved highest levels of reduction in Vulpia hairgrass with good levels of crop safety.

Key points: Small broomrape

- The parasitic weed small broomrape is becoming an increasing issue in clover seed crops.
- Chemical control options for small broomrape are limited.
- A model was able to predict the emergence of broomrape plants to within a week, for sites between Ashburton, Rakaia and Methven.

Managing Vulpia hairgrass in ryegrass

Vulpia hairgrass (*Vulpia* sp.) is a common and problematic grass weed in ryegrass (*Lolium perenne*) seed production, impacting both yield and quality. The primary herbicide used to control Vulpia hairgrass in ryegrass seed crops is Nortron® (active ingredient (a.i.) 500 g/L ethofumesate, Group 15 Herbicide). The use of Nortron® in crops like ryegrass poses a significant risk of resistance developing in common grass weed species, especially if applied following cereal crops treated with Firebird® (a.i. 400 g/L flufenacet + 200 g/L diflufenican, Group 15 Herbicide + Group 12 Herbicide), since the actives in both herbicides share the same mode of action (Group 15).

To combat resistance in Vulpia hairgrass, it is essential to incorporate herbicides with diverse modes of action and integrate them with other effective weed management practices. Therefore, it is crucial to identify herbicides that can be used as alternatives to Nortron® that are capable of effectively controlling Vulpia hairgrass at various growth stages in ryegrass seed crops. Previous FAR trials (2018-2019) showed that Nortron®, applied at the 2-leaf stage of Vulpia hairgrass (Zadok's growth stage (GS) 12), was moderately effective, but less effective when applied later. Therefore, the main objectives of this work were:

1. To assess the effectiveness of various pre- and post-emergence herbicide options for Vulpia hairgrass control in ryegrass seed crops.
2. Identify herbicides that could be used as potential alternatives to Nortron® for controlling Vulpia hairgrass in ryegrass seed crops at different application timings.

2023-24 trial details

Treatments were applied at two different timings, either at the pre-emergence of ryegrass (GS 00- 07) (T1), 27 April 2023, or when 50% of plants were at 2-leaf stage (GS 12) (T2), 12 June 2023. The number of emerged ryegrass plants per plot was determined by counting all ryegrass plants present within two 0.5 m rows (11 August 2023). The level of Vulpia hairgrass control was recorded on a plot basis relative to the untreated control on 25 August 2023 using a scale of 0% to 100%, where 0% = no control and 100% = full control. Treatments were assessed on a plot basis for phytotoxicity and biomass reduction on 25 August 2023 using a scale of 0% to 100%, where 0% = no damage and 100% = all plants dead with no green leaf.

Results

Overall, the highest levels of efficacy were achieved by the treatments that were applied at the pre-emergence timing of the ryegrass. Nortron® applied at the pre-emergence stage solo at 4 L/ha (Treatment 2) or followed at early post emergence with either 2 L/ha of Prominent® (Treatment 4) or 4 L/ha of Asulox® (Treatment 5) achieved the highest levels of Vulpia hairgrass control with acceptable levels of crop safety for the ryegrass (Figure 1). Splitting the 4 L/ha application of Nortron® into two separate 2 L/ha applications with Prominent® applied at 2 L/ha (Treatment 9) at timing 2 also provided satisfactory levels of Vulpia hairgrass control and ryegrass crop safety, indicating the value of using Prominent® early after emergence of ryegrass. Applying Prominent® at 2 L/ha in a tank mix with 4 L/ha of Nortron® during pre-emergence (Treatment 3) or with 500 mL/ha of Atraflow™ and 80 g/ha of Sakura® (Treatment 16) post emergence effectively controlled Vulpia hairgrass. However, these treatments caused significant ($P≤0.001$) reductions in the number of plants in treated plots (Table 1) due to the considerable phytotoxicity damage to ryegrass. It is likely that this damage will persist through to flowering resulting in low numbers of ryegrass seed heads being present at harvest causing yield to be heavily impacted.

Table 1. Mean and total number of emerged perennial ryegrass (*Lolium perenne*) plants per two 0.5 m rows in plots treated with 17 different treatments at FAR Chertsey research site, 11 August 2023.

Treatment No.	Product[1], Application Rate and Timing		Mean plants per two 0.5 m rows	Total Plant Count
	Pre-emergence (GS 00-07) 27 April 2023	Early post-emerge 2-leaf (GS 12) 12 June 2023		
1	Untreated	-	18 cde	144
2	Nortron® (4 L/ha)	-	21 abcde	168
3	Nortron® (4 L/ha) + Prominent® (2 L/ha)		8 f	63
4	Nortron® (4 L/ha)	Prominent® (2 L/ha)	24 a	193
5	Nortron® (4 L/ha)	Asulox® (4 L/ha)	21 abcd	174
6	Nortron® (4 L/ha) + Quantum® (100 mL/ha)		18 bcde	146
7	Nortron® (4 L/ha)	Invado® (250 mL/ha)	17 de	138
8	Nortron® (2 L/ha)	Nortron® (2 L/ha)	22 abc	176
9	Nortron® (2 L/ha)	Nortron® (2 L/ha) + Prominent® (2 L/ha))	23 a	191
10		Nortron® (4 L/ha)	22 ab	181
11	Headstart® (1 L/ha)	Nortron® (4 L/ha)	22 a	183
12		Nortron® (4 L/ha) + Quantum® (100 mL/ha)	25 a	204
13		Nortron® (4 L/ha) + Simatop™ (0.5 L/ha)	25 a	203
14		Nortron® (4 L/ha) + Protugan® (0.75 L/ha) + Prominent® (2 L/ha)	22 abcd	174
15		Sakura® (80 g/ha)	17 e	135
16		Prominent® (1.2 L/ha) + Atraflow™ (500 mL/ha) + Sakura (80 g/ha)	10 f	80
17		Nortron® (4 L/ha) + Protugan® (0.75 L/ha) + Quantum® (100 mL/ha)	22 abc	178
		LSD ($P≤0.05$)	4.5	-
		***P* value**	<0.001	-

Letters indicate significant difference at $P≤0.05$ according to Least Significant Difference (LSD)[1] Asulox® (a.i. 400 g/L asulam, Group 18 Herbicide); Atraflow™ (500 g/L atrazine, Group 5 Herbicide); Headstart® (50 g/L flumetsulam, Group 2 Herbicide); Invado® (a.i. 400 g/L flufenacet, Group K3 Herbicide); Nortron® (a.i. 500 g/L ethofumesate, Group 15 Herbicide); Prominent® (500 g/L prometryn, Group 5 Herbicide); Quantum® (a.i. 500 g/L diflufenican, Group 12 Herbicide); Sakura®850 WG (850 g/kg pyroxasulfone, Group 15 Herbicide); Simatop™ (a.i. 500 g/L simazine, Group 5 Herbicide); Protugan® (500 g/L isoproturon, Group 5 Herbicide).

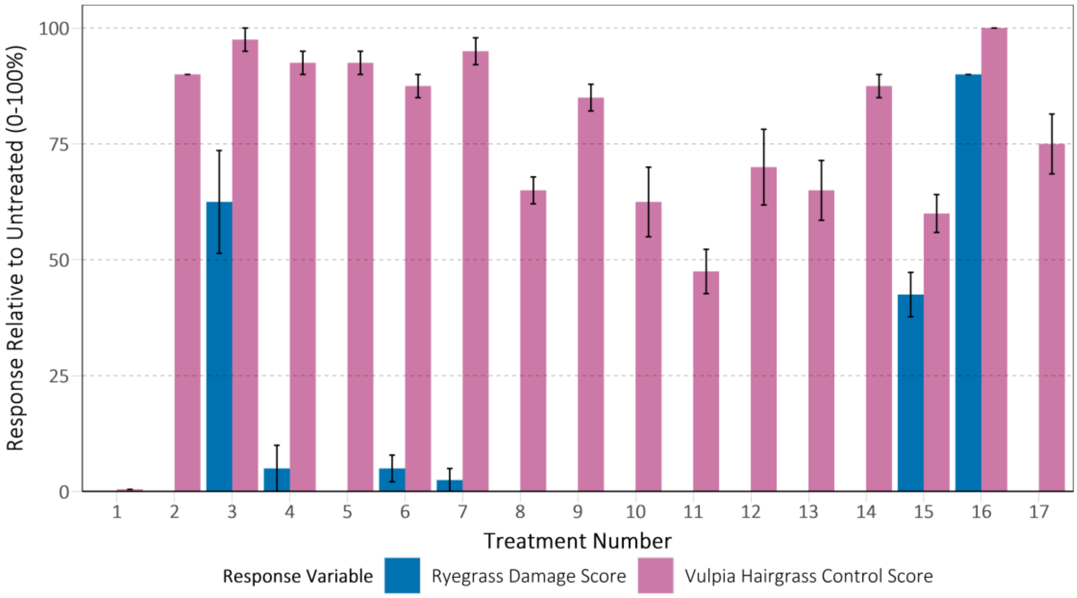

Figure 1. Ryegrass damage and Vulpia hairgrass control scores relative to the untreated control (Treatment 1) 10 weeks after application of pre-emergence herbicide treatments on 25 August 2023.

Control of small broomrape in clover

Background

- The parasitic weed small broomrape (*Orobanche minor*) is an increasing issue in clover seed crops.
- Small broomrape is a notifiable weed in some countries, e.g. USA.
- It is becoming hard for seed companies to find crops which pass field inspection for some markets, particularly South America.
- Small broomrape spends most of its lifecycle below ground where it undergoes germination, penetration of the host, vascular connection and acquisition of nutrients.

- A single plant is capable of producing 500,000 seeds. Once seed is dispersed into soil, it may remain viable for up to 50 years.
- Small broomrape seed will not germinate without a host or "false host" plants present.
- While several "false hosts", including wheat, ryegrass, barley, oats and tall fescue, can trigger germination, broomrape is incapable of sustaining growth on these species, thus reducing the soil seed count. However, relying on this method as an effective strategy for controlling broomrape is not recommended.
- Mature flower stalks are typically 10 to 50 cm tall and do not contain chlorophyll (Figure 2).

Figure 2: Small broomrape inflorescence emerging, 9 November 2022, near Chertsey

Strategies for controlling small broomrape in clover seed crops

Chemical control options are limited. Soil applied herbicides have little effect as small broomrape sources its nutrients and water from the host plant. Similarly, herbicides which attack photosynthetic pathways are ineffective, as broomrape does not photosynthesize.

- Realistic control options, if terminating the crop, include glyphosate, paraquat/diquat and ALS inhibitors (imidazolinones and sulfonylureas). In clover crops, imazamox and imazamox plus bentazon have shown some promise in limiting emergence and being crop safe (e.g. in Oregon on red clover, Lins et. al. 2005 https://www.jstor.org/stable/3989726). However, imazamox is not available in New Zealand.
- A growing degree day model has been developed in Oregon for small broomrape parasitising red clover crops to optimise herbicide timings.
- We have no hard data on crop loss from infection, but it is not believed to be large in healthy irrigated crops. Crops under stress (e.g. dryland) may exhibit more substantial losses.

Observations of small broomrape in clover during the 2022-23 season in New Zealand

- The model predicted the start of emergence to within a week for sites between Ashburton, Rakaia and Methven.
- Small broomrape was first reported near Chertsey in early November.
- Additional reports came throughout November, mainly in second year clover crops.
- First mature seed found 22 December 2022. Note literature suggests that if it has started flowering, it doesn't matter what you do, even if it is cut off it will still produce viable seed.
- Monitoring continued until February when crops were desiccated, both paddocks still had inflorescence emergence occurring.
- The control window appears to run from late October though to at least January.

Trial being conducted at Chertsey Arable site, 2023-24

Seed was spread last season over the clover trial. Equate® (active ingredient (a.i.) imazethapyr) and Preside™ (a.i. flumetsulam) were chosen as they are the most closely related chemistries to Imazamox available in New Zealand. Oregon's growing degree model was developed to identify a herbicide application window as literature suggests that chemistry must be applied well before emergence to be effective.

Treatment No. [1]	Timing 1 25 September 2023	Timing 2 13 October 2023	Timing 3 ~16 November 2023
1	Negative Control		
2	Equate® (400 mL/ha) + Hasten™ (500 mL/100 L)		
3	Equate® (400 mL/ha) + Hasten™ (500 mL/100 L)	Equate® (400 mL/ha) + Hasten™ (500 mL/100 L)	
4	Equate® (400 mL/ha) + Hasten™ (500 mL/100 L)		Equate® (400 mL/ha) + Hasten™ (500 mL/100 L)
5	Preside™ (1 L/ha)		

[1] Equate® (a.i. 240 g/L imazethapyr, Group 2 Herbicide); Hasten™ (704 g/L ethyl and methyl esters of canola oil fatty acids with 196 g/L non-ionic surfactants); Preside™ (800 g/kg flumetsulam, Group 2 Herbicide)

Autumn management of multi-year grass seed crops

Richard Chynoweth and Chris Smith, FAR

Key points

- Early opportunities for tiller appearance by autumn management is critical for seed head formation in tall fescue and cocksfoot, this is less critical in other grass species.
- To stimulate tiller emergence, light is required at the base of last year's tillers, following which, tillers must reach a certain size to be vernalised before the end of winter.
- Autumn management that removes the previous season's residue will promote tiller growth and maximise the number of reproductive tillers.
- Residue management, soil fertility and soil moisture status influence autumn tillering.

Background

In multi-year grass seed crops, the number of seed heads/m^2 is the primary yield component to influence potential seed yield. Optimum seed head numbers range from ~400 in tall fescue through to 1800 in perennial ryegrass (*Lolium perenne*). Seed head number is determined by the number of tillers, or in some cases buds, exposed to winter environmental cues for reproductive development. Winter requirements range from nil (some *Poa*, and *Phleum* species), to intermediate (cocksfoot and perennial ryegrass) and strong (tall fescue).

Where winter requirements are greater, post-harvest crop residue management is crucial to attain optimal seed yield in the subsequent season. The seed heads which form the basis of the next harvest begin as vegetative tillers the previous summer/autumn. In tall fescue, tillers have a juvenile phase and must reach a certain size before they can be vernalised. In grasses, tillers begin life as a bud, under a leaf sheath and to grow into tillers, they must receive light stimulus. When dense crop canopies capture all the light e.g. during summer when a seed crop has good seed head numbers, buds located near the base are shaded and dormant. At harvest, the crop is swathed and harvested and light reaches the base, releasing new tillers. However, if crop residue or a large canopy remains, this may intercept sunlight and restrict tiller emergence, and subsequent growth rates. Thus, post-harvest management must allow tillers to grow during autumn and early winter. The presence of straw, debris, or standing stubble can reduce tiller growth, ultimately reducing potential seed yield.

Tall fescue trial

Tall fescue cultivars, Quantica and Temora, were sown during the summer of 2021-22 and managed as a seed crop during the 2022-23 growing season. Plots were direct harvested in mid-December. Following harvest, all plots were cut to 15 cm using a windrower and the foliage removed by hand raking. On 23 Jan 2023, treatments with a 7 cm cutting height were cut using a plot windrower; foliage was removed approximately 14 days later. Subsequently, plots were kept trimmed to their respective heights until the end of June. All plots received 50 kg N on 29 March, applied as SustaiN®.

In June, all treatments had ~4000 vegetative tillers/m^2 (data not shown). Seed head number was assessed 9 November by counting the number of seed heads on 30 cm of row at two locations in each plot. The seed head number was influenced by cultivar only, no differences in seed head numbers were observed between treatments. Note: 'Temora' is later heading than 'Quantica' and that seed heads were still emerging in many Temora treatments.

Table 1. Seed head number per m^2 for two cultivars of tall fescue assessed on 9 November 2023 following autumn trimming at two heights and winter inter-row spraying as post-harvest management options when grown at the FAR Chertsey Arable Research Site, Mid Canterbury during the 2023-24 growing season.

Cultivar or treatment	Topping height (cm)			Cultivar mean
	7 cm	7 cm	15 cm	
Interrow sprayed	**No**	**Yes**	**No**	
'Quantica'	313	264	279	280 a
'Temora'	219	195	226	212 b
Treatment mean	**266**	**230**	**253**	
	P value	**$LSD_{0.05}$**		
Cultivar	<0.001	45.3		
Height	0.577	NS*		
Interrow spraying	0.125	NS		
All interactions	**>0.326**	**NS**		

* = Not significant

Autumn irrigation management

It is preferable to install moisture monitoring as soon as possible after a crop is sown. This allows the probe good time to bed in, and means it is placed in an actively growing crop. This allows you to track crop development and monitor potential limitation from soil moisture and soil temperature. Different types of probes offer different sets of data.

- Single level probes are generally placed at 10 or 20 cm. If installed too deep you miss initial root moisture use; too shallow and they will be too reactive to conditions.
- Sensors giving average reading over a length, such as a 3m tape with a depth running from 10 cm to 40 cm, monitor fewer, greater amounts of soil and, when the crop is further developed, give a good reflection of the moisture in that 40 cm zone. However, the average moisture between 10-40 cm may not be as relevant in young crops as it would be in the spring when crop roots have had time to develop. Beware that if crop roots are not taking moisture from that depth, readings will not reflect available water to your ryegrass.
- Multi-level moisture sensors can be set up to show only the sensors where the roots are actively growing, but make sure that the rooting zone is set up correctly. In an establishing crop, roots will be shallow and only drawing moisture from the top sensors. So, if your probe is set with a rooting zone down to 40 cm or deeper, again, it will assume the plant has access to more available water than the roots can extract it from. Being able to increase the rooting zone as the crop develops provides another useful layer of information.

Moisture monitoring terminology, points of reference:

- **Field capacity:** The point where the soil pores are full and the soil cannot hold any more water without drainage.
- **Stress point:** The readily available water in the profile. For a plant to take moisture from soil below this point requires energy, and prolonged time below stress point can impact on crop development. Stress point is a moving figure, but most systems show it as a static line.

- **Moisture trace:** This is the moisture from the sensors (depth) included in the rooting zone (10 cm, 20 cm and potentially 30 cm, but will be deeper as the crop continues to grow).

Most probes, especially capacitance probes, provide a soil moisture trend, so arguably, having them set up correctly for the field capacity and stress point (based on soil and crop type) and adjusting for growth stage (root zone depth), is of greater value than having them calibrated scientifically.

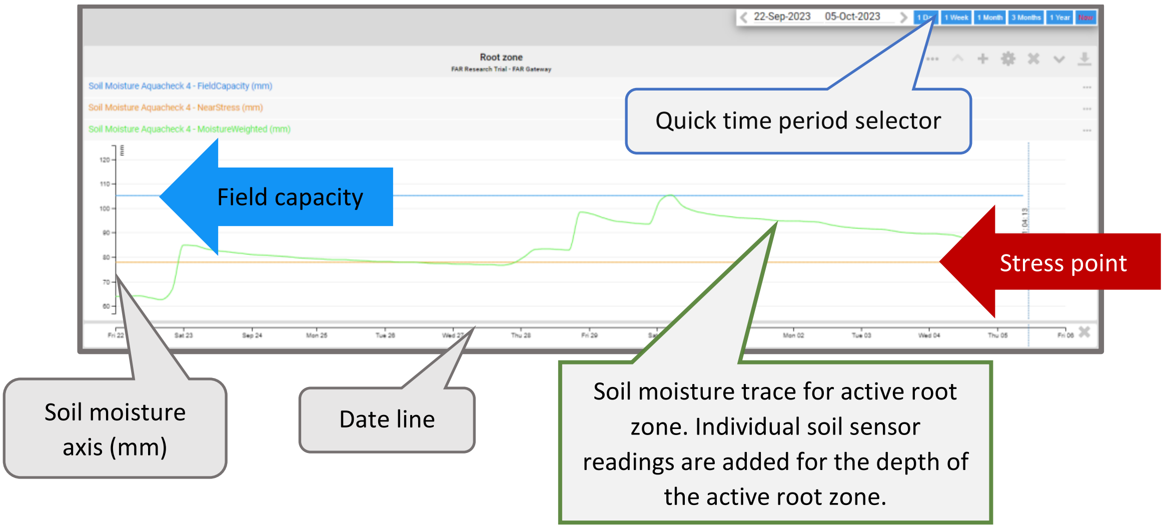

Figure 1. Soil moisture sensor display.

Y-axis: Left hand axis displays mm for soil moisture and parameters (Field Capacity and Stress Point). Have these been set up correctly with the correct number of sensors that reflect the rooting depth?

Time X-axis: Is it easy to change the time period for the soil moisture plot? It is advisable to select a minimum of 14 days to get a good indication of the change in soil moisture trend.

If crops are irrigated too early in their development, there is potential for the roots to stop searching for moisture deeper down in the profile. This may alleviate any immediate potential moisture stress, but it could have repercussions later on in the year when the roots haven't developed as deeply as they could of. This could make the crop potentially more vulnerable to drought, as it can't access moisture at a deeper level.

Most years, as you get further into autumn, the soil is naturally cooling down. Applying water may cool soil temperatures further. This may in itself reduce grow rates and nutrient uptake.

If you do decide that the impact of not watering your ryegrass crop presents a greater issue to the crop than any of the above factors, then make sure you are aware of the weather forecast and only apply as much water as needed. Never fill the profile, only go to field capacity. Exceeding field capacity is not only a waste of irrigation, it has potential to move nutrients below the root zone where they may become an environmental issue. Leave enough of a soil moisture deficit (the mm of moisture the roots have access to, below field capacity), that if the weather does change there is enough room in the root zone to utilise any rain event without it creating unintended issues. Free moisture is always the best moisture!

Crop competition to manage weeds

Pieter-Willem Hendriks (Lincoln University) and Matilda Gunnarsson (FAR)

Key points

- Weeds are causing potential losses of up to 35% of global crop production.
- Enhancing the capacity of wheat to compete with weeds offers a cost-effective solution without requiring farmers to adopt new techniques or equipment.
- Faster canopy closure is associated with the capacity of wheat to compete with weeds.
- Light interception measurements in the Chertsey CPT trial (2023-2024) show that different cultivars have significantly different rates of canopy closure from early growth onwards.

Background

Weeds are a significant challenge in global wheat production, competing with the crop for essential resources and causing losses of up to 35% of global crop production. While the current agricultural system manages to keep weed pressure within 10% of yield loss, it comes with its own set of problems, including herbicide resistance, soil erosion, and the presence of chemical residues in food and water. The cost of herbicide resistance, coupled with increasing legal constraints on pesticide development, emphasizes the need for integrated weed management.

Historically, wheat had the advantage of shading out weeds due to its tall growth, but this came with risks of lodging and reduced harvest index. The Green Revolution focused on increasing yields and reducing above-ground biomass and leaf area, which inadvertently reduced crop competitiveness with more open canopies allowing more light penetration and weed growth. Additionally, modern wheat cultivars have smaller root systems, further impacting their competitiveness against weeds.

Enhancing the capacity of wheat to compete with weeds offers a cost-effective solution without requiring farmers to adopt new techniques or equipment. Crop competitiveness is the combination of crop tolerance to weed competition and its ability to suppress weeds.

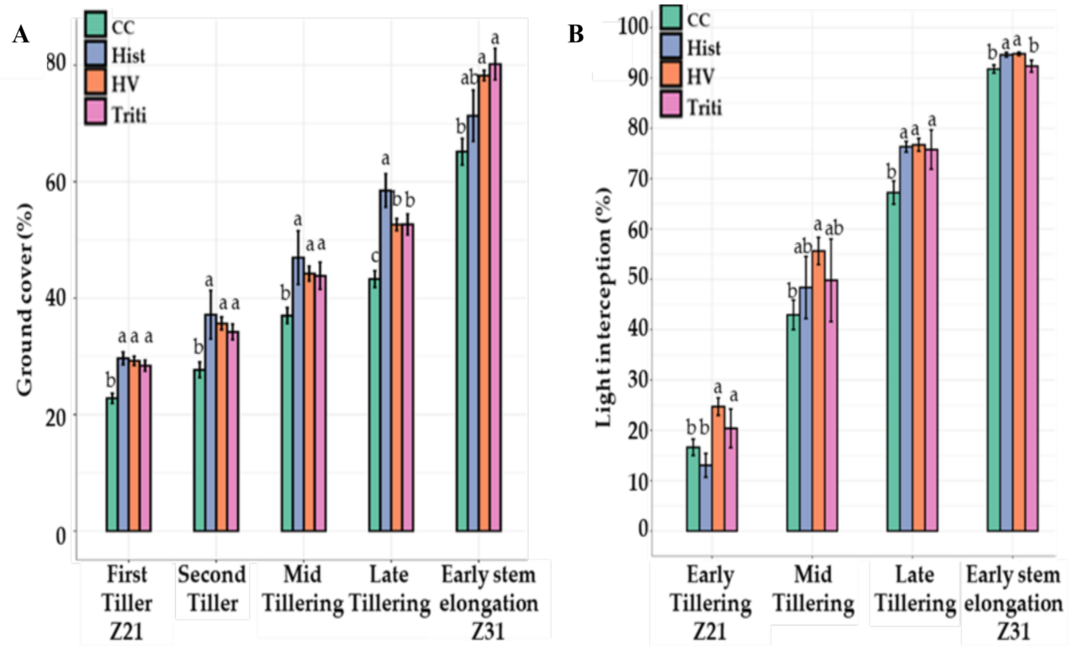

Figure 1. 2020 Field trial results (Australia) showing a comparison of canopy growth and light interception of vigour lines (HV, orange) compared to five commercial cultivars (CC, green), a historical wheat variety (Hist, blue), and triticale (Triti, pink, n = 10).

Wheat cultivars that close their canopy faster and shade out weeds are more competitive. Notably, the development of early shoot vigour in wheat has been successful, increasing leaf width and area, which aids in faster canopy closure and weed suppression (cf first block). These differences in light interception account for approximately 50% of the increased suppressive ability of the vigorous lines.

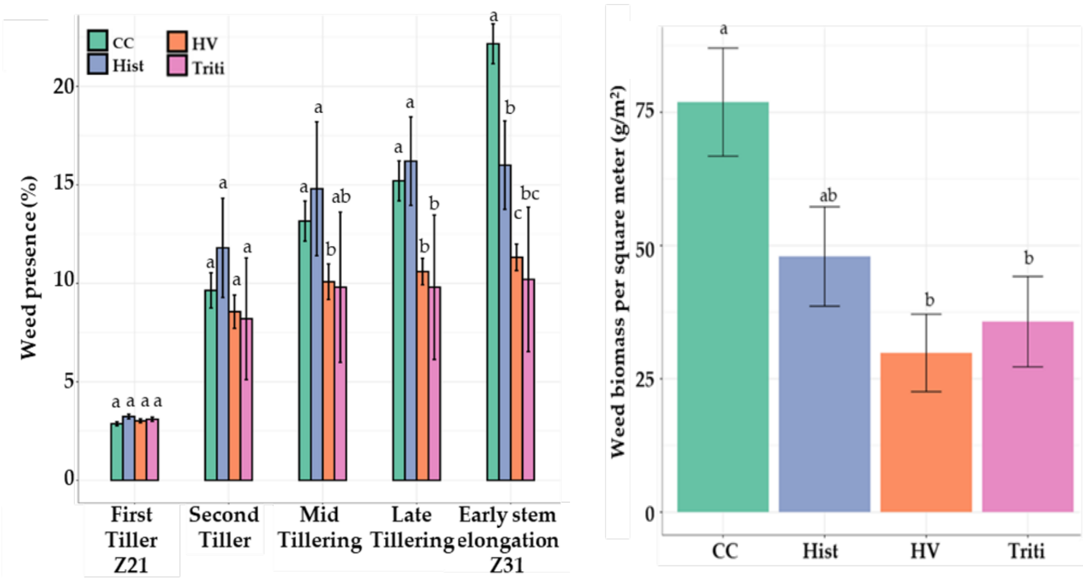

Figure 2. 2020 Field trial results (Australia) showing weed presence and biomass under vigour lines (HV, orange) compared to five commercial cultivars (CC, green), a historical wheat variety (Hist, blue), and triticale (Triti, pink).

Testing light interception of wheat cultivars grown in New Zealand

FAR and Lincoln University are investigating whether it is possible to detect differences in light interception in the early stages of growth in New Zealand wheats. To do this, we are initially comparing cultivars/lines in the CPT2 trial at the Chertsey Arable site. Results collected to date (see below) suggest some significant differences in light interception from early growth onwards.

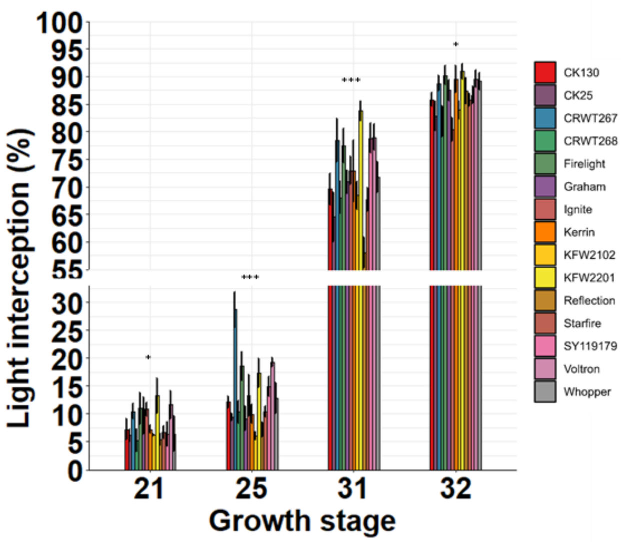

Figure 3. 2023 Field trial results at Chertsey, showing light interception by different cultivars from early tillering to second node growth stage. * indicates significant differences. *** indicates highly significant differences between cultivars.

Extending the value of ryegrass seed crops

Abie Horrocks (FAR) and Peter Mitchell (North Otago farmer)

Key points

- Over-drilling ryegrass re-growth after seed harvest with a legume resulted in greater biomass and improved quality (compared to re-growth without a legume).
- Residual soil mineral nitrogen (N) was low after the ryegrass seed crop was harvested, but the continued mineralisation in summer and autumn (and possibly legume generated N) provided enough N for growth over the winter without applying N fertiliser.
- Continued decomposition of legume residues under the subsequent spring-sown crop has further N advantages that can be capitalised on.
- Choosing the right legume will depend on conditions when over-drilling. If conditions are dry and firm, large seeds will be less successful. If there is already a lot of ryegrass re-growth competition, smaller seeds may not achieve the required soil/seed contact.

Background

Ryegrass seed crops are commonly followed in the rotation by an autumn cereal such as wheat. However, this option is growing increasingly challenging in some areas due to post-emergence herbicide resistance in ryegrass (Ngow et al., 2020). An alternative is to maximise the benefits of the ryegrass seed crop by using the re-growth as the basis for winter feed. The viability of adding legumes into post-harvest ryegrass re-growth to further extend the value of the crop by providing high quality feed and reducing the N fertiliser spend for the next year is also of interest, particularly as the percentage of farm expenses made up of nitrogenous fertiliser is frequently over half.

Methods

Two trials were used to assess drilling legumes into ryegrass re-growth.

1. The Chertsey Establishment Trial (CET) measured biomass and N supply from adding faba beans (*Vicia faba L*.) to ryegrass re-growth under different tillage and irrigation scenarios.
2. A trial at Kowhai farm to compare establishment of small and large seeded legumes over-drilled into ryegrass re-growth (biomass and quality were measured).

At the CET, dryland ryegrass harvest was completed by 2 Feb. 2023 and irrigated harvest by 12 Feb. 2023. Faba beans were direct drilled at 60 kg/ha on 3 March 2023 into ryegrass re-growth. The trial was grazed by autumn born R1 dairy calves for 4 days from 27 April 2023. Soil sampling was carried out 2 Feb. 2023 (0-30, 30-50 cm) and 4 Aug. 2023 (composited by tillage treatment within rep) and lab analysed for mineral N. Quick test assessments were also carried out on 4 Aug. 2023 samples. Penetrometer readings were taken on 17 April 2023. Biomass cuts were taken prior to grazing (24 April 2023) and were composited by rep. Biomass cuts taken 3 months after grazing (4 August 2023) were composited by tillage treatment within rep. Peas were drilled at 25 kg/ha on 3 Oct. 2023.

At Kowhai, four legume species: small seeded (< 100g per 1000 seeds); Berseem (*Trifolium alexandrinum* L.), Balansa (*Trifolium michelianum*), Hairy vetch (*Vicia villosa*)) and large seeded legumes (500—700 per 1000 seeds; Faba beans) were over-drilled into ryegrass re-growth, at 7, 4, 40 and 40 kg/ha respectively, on 6 April 2023. These were compared to controls of annual (cv. Tama) or perennial (cv. Base) ryegrass re-growth. Biomass assessments from each plot were carried out 16 August 2023. DM was determined and samples went to Hill Laboratories for feed quality analyses.

Results

There were no significant effects of tillage (P=0.523) or irrigation (P=0.186) on ryegrass seed yields which averaged 1660 kg/ha. Faba beans were direct drilled into the ryegrass re-growth during very dry conditions. This was noticeably problematic in the dryland reps and no-tillage plots (desired seed depth was 2 inches but actual depth was variable, 1-3 cm). Although the first biomass cut data were unable to be analysed, the data suggest greater biomass in the irrigated compared with the dryland reps and there was more successful faba bean establishment in the irrigated plots (Figure 1).

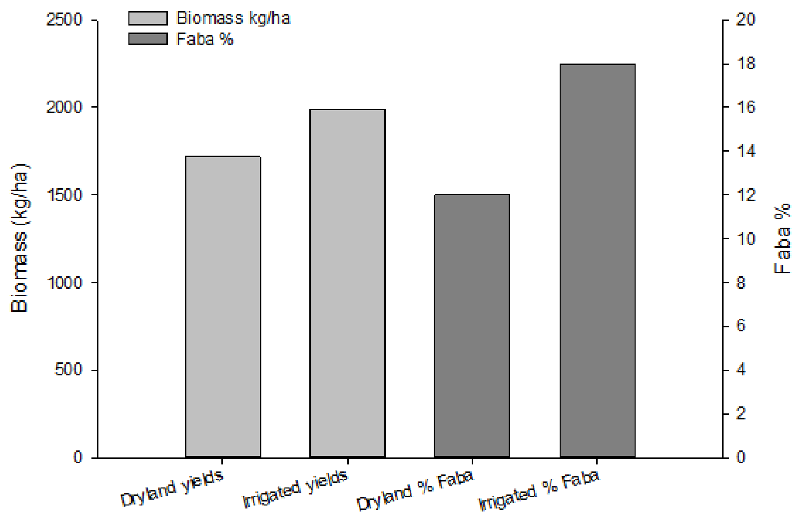

Figure 1. Pre-grazing (24 April 2023) total biomass (kg/ha), left axis, and percentage of the mix made up of faba beans, right axis (%).

Three months after grazing, there was significantly greater faba bean re-growth in the irrigated plots (48%) compared with the dryland plots (17%) (P=0.023). Overall biomass of the faba and ryegrass re-growth was greater in the irrigated reps for inversion and non-inversion but not for no-tillage (P<.001, Figure 2).

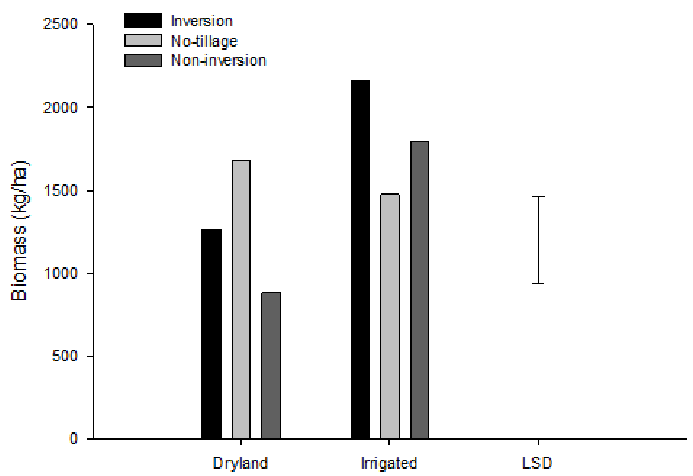

Figure 2. Biomass yield (kg/ha), for ryegrass + faba bean mix at three months after grazing (4 August 2023). Error bar represents the Least significant difference ($LSD_{5\%}$) for the interaction.

Faba beans did not re-establish well after grazing in the no-tillage plots (P<.001), with 22%, 36% and 41% faba bean for the no-tillage, inversion and non-inversion respectively, presumably because they never established well in the no tillage plots. Penetrometer readings were also significantly greater in the no-tillage plots (P<0.001) indicating greater firmness, which would have made establishing the faba beans more challenging given the dry conditions.

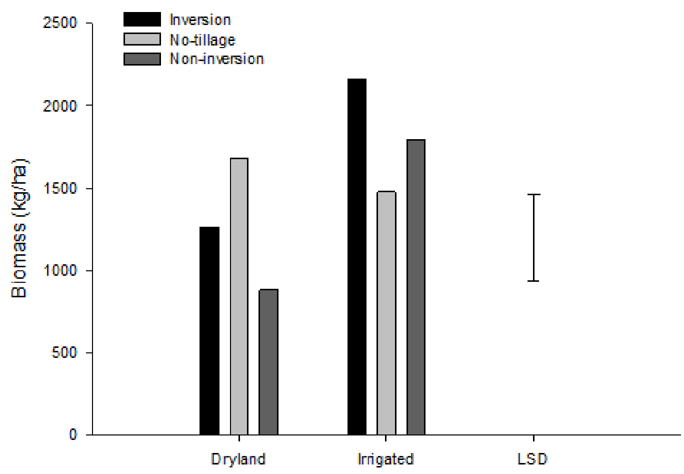

Figure 2. Biomass yield (kg/ha), for ryegrass + faba bean mix at three months after grazing (4 August 2023). Error bar represents the Least significant difference ($LSD_{5\%}$) for the interaction.

Overall yields did not appear to be compromised where faba beans established well, compared to where establishment was poor. However, the quality of the grazing (as measured by N concentration) tended to be greater where there was a higher percentage of faba beans (Figure 3).

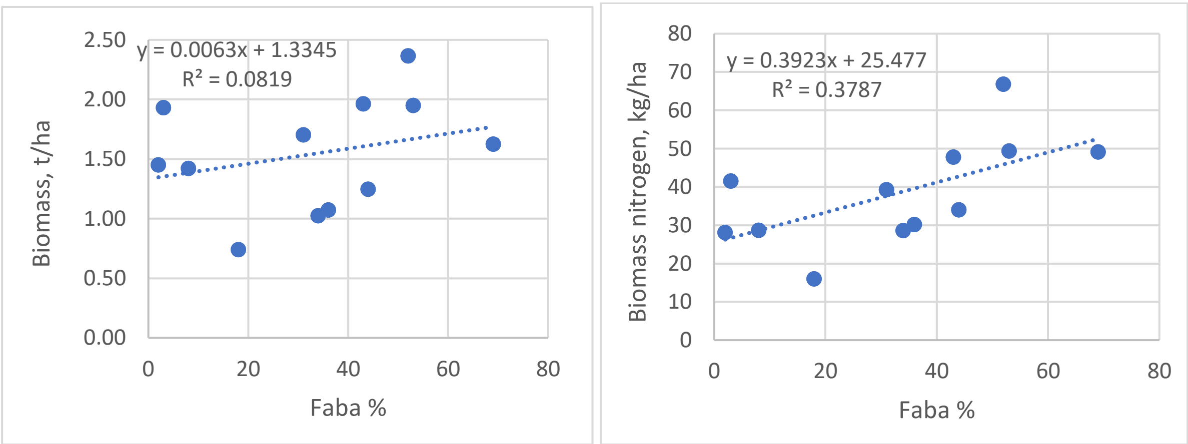

Figure 3. Biomass (faba + ryegrass, t/ha) and biomass nitrogen, kg/ha, for the different percentages of faba, three months post grazing, 4 August 2023.

There was very little soil mineral N in the top 50 cm after the ryegrass harvest (7.4 kg/ha; range=5-13 kg N/ha) and soil mineral N remained low three months after the grazing event, averaging 3.8 kg N/ha (range=3-6 kg N/ha). Quick N test and laboratory mineral N tests were well correlated (data not shown). Despite low soil mineral N, there was 39 kg N/ha in the above ground biomass pre-grazing (on average). Some of this would have been removed with the grazing event, some would have remained un-grazed and some would have been returned via dung and urine. Three months after grazing there was on average 41 kg N/ha in the above ground biomass.

Given no fertiliser N was applied and the low soil mineral N at drilling, this N came from further mineralisation and N fixation generated from the faba beans. Trials at FAR's North Crop Research Site (Waikato) suggest that when comparing legumes, monocots and mixes of the two; in the mixes the monocot benefits from legume generated soil N. This is an area that requires more investigation.

At the Kowhai trial site, the small seed legumes (vetch, balansa and berseem) failed to establish and this was attributed to either: the fact that the ryegrass had re-grown, making it difficult to adequately drill the smaller seeds into the soil (i.e., reduced soil/seed contact) or reduced ability of seedlings to compete with the already established ryegrass. However, the large seeded faba bean established well. Dry matter quantity and quality (e.g., crude protein; CP) were greater for the faba bean/ ryegrass mix compared with the ryegrass control (Table 1).

There were no differences in neutral detergent fibres (NDF) and acid detergent fibre (ADF) between the control and control + faba bean for cv. Base, but the control + faba bean had higher ADF and NDF values for cv. Tama ryegrass. Metabolizable energy (ME) was not affected by inclusion of faba bean for both grass types. Quality attributes reported here were close to or well above the recommended optimum for animal requirements (Nichol et al., 2003; NRC, 2000).

Table 1. Effects of over-drilling faba beans in perennial (cv. Base) and annual (cv. Tama) ryegrass on feed quality[1]. Optimum concentrations for beef cattle production (NRC, 2000; Nichol et al., 2003).

Ryegrass	Legume	Total DM (kg/ha)	CP (%)	CP Yield (kg/ha)	NDF (%)	ADF (%)	ME (MJ/ kg DM)
Base (perennial)	Control (Base)	3016	11.4	349	49.5	27.8	10.2
	Faba	3500	14.8	519	50.0	27.8	10.2
	Mean	***3231***	***12.9***	***424***	***49.7***	***27.8***	***10.2***
Tama (annual)	Control (Tama)	2412	18.8	456	49.5	28.2	9.10
	Faba	2644	20.2	529	52.5	30.7	8.90
	Mean	***2515***	***19.4***	***488***	***50.9***	***29.3***	***9.0***
SEM		166	0.88	28.5	0.48	0.34	0.17
Optimum		**—**	**≥12**	**—**	**≥33**	**≥21**	**10—11**

[1]CP=Crude protein; NDF=neutral detergent fibres; ADF=acid detergent fibre; ME=metabolizable energy and NSC=non-structural carbohydrates.

Conclusion

Over-drilling ryegrass re-growth after seed harvest with a legume resulted in greater biomass and improved quality (compared to re-growth without a legume). Timing of drilling and soil conditions are important considerations. Dry and firm soil conditions may affect success of over-drilling larger seeds, while smaller seeds may struggle with competition. Carrying out a trial on drilling the smaller seeded legumes at an earlier sowing date is required to better understand these dynamics.

Residual soil mineral N was low after the ryegrass seed crop was harvested but continued mineralisation of N carried the grasses through, while the legumes were expected to fix most of the N they needed for growth. Little is known about the benefit of N fixation to the companion crop, an area that still needs to be studied. As the legume continues to decompose in the subsequent spring crop further N advantages are expected and soil testing (PMN) would be recommended to ensure this is capitalised on.

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Fungicide stewardship - learning from the past to protect our future

Jo Drummond (FAR) and members of the Fungicide Resistance Industry Initiative

Key points

- Disease control strategies have changed over the last 50 years as more has been learned about diseases, cultivars and resistance management.
- However, the fundamentals of managing disease such as selecting a resistant cultivar and choosing an appropriate fungicide programme are largely unchanged.
- Fungicide programmes have become more complex and intensive, with multiple mode of action (MoA) groups and timings to achieve balance between productivity, profitability, disease control and resistance management.
- With the threat of fungicide resistance in our key mode of action groups, we need to do all we can to protect our chemistry and cultivars to retain their long-term use.

Background

Adapting to changes in pesticide practices involves navigating regulation, registration, resistance development and residues. Comparing today's challenges with those faced by past generations, who coped with diseases, pathogen shifts and chemistry withdrawals, offers valuable insights for effective strategies for the future.

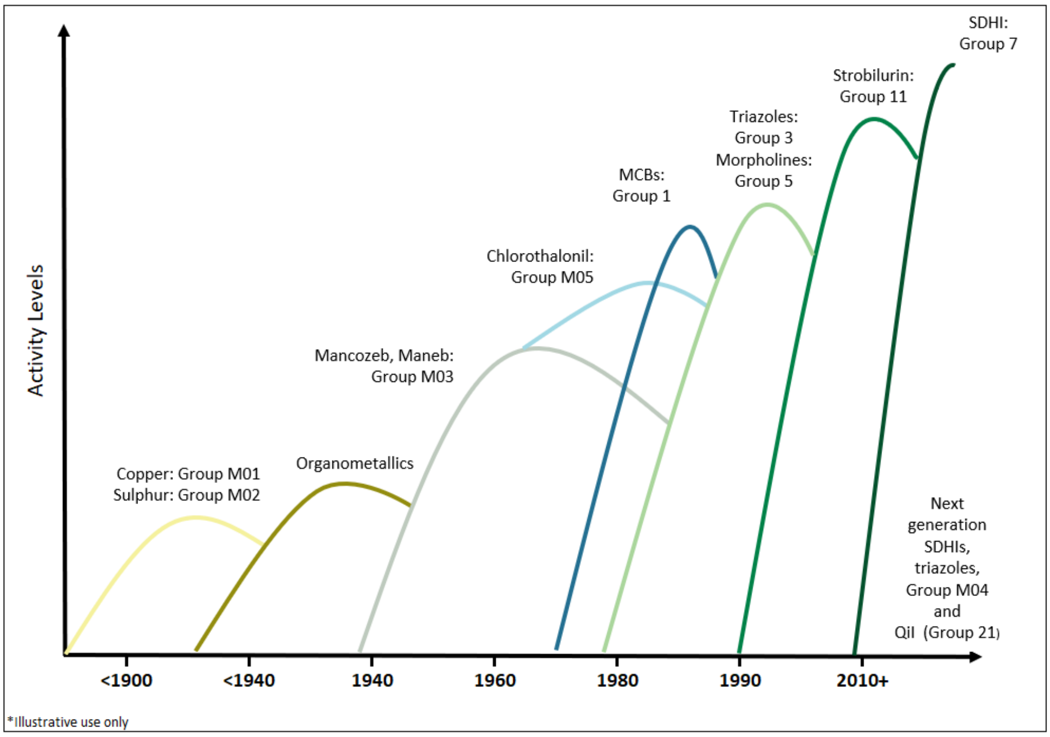

Figure 1. The evolution of fungicide mode of action groups. Source: Kevin Manning, Fruitfed Supplies.

1970s

Over 70 years, wheat yield increased by almost 70% (3-4 t/ha). During the 1970s, target diseases were powdery mildew and leaf rust, which saw the introduction of methyl benzimadozole carbamates (MCBs) (Group 1) and morpholines (Group 5), such as Benlate® (benomyl – Group 1) and Calixin® (tridemorph – Group 5) (Figure 1). Resistant cultivars were available, but these were vulnerable to new pathogen strains (Blair 1972). Disease management programmes often consisted of a single foliar application at the first signs of disease, which was successful until the discovery of stripe rust (*Puccinia strifdormis*) in Southland in 1980 (Harvey and Beresford 1982).

1980s

In the 1980s, wheat yields were around 5 t/ha. Stripe rust spread rapidly and devastated susceptible cultivars, which made up the bulk of wheat cultivars grown. Yield losses of up to 50% were reported (Harvey and Beresford 1982).

Control measures for stripe rust were integrated into disease management programmes without causing a significant reduction in national yield (Cromey et al 1992). First-generation triazoles (Group 3 fungicides) became a key part of ongoing disease management programmes (Figure 1). Triazoles like Bayleton® (a.i. triadimenol), Tilt® (a.i. propiconazole), Bayfidan®/Cereous® (a.i. triadimenol) and Sportak® (a.i. prochloraz) and morpholines (Group 5) such as Corbel® (a.i. fenpropimorph) were used to control stripe rust, leaf rust, powdery mildew and STB.

Breeding programmes developed resistant cultivars such as 'Otane' (Cromey et al 1992), but often cultivars were resistant to one disease but not others such as 'Kotare' (Cromey and Hansen 1992). Fungicides started to overcome these limitations, forming the basis for the modern cultivar/chemistry approach.

1990s

Irrigated wheat yields jumped to around 9 t/ha in the 1990s. Second-generation triazoles (Group 3) like Folicur® (a.i. tebuconazole) and Opus® (a.i. epoxiconazole) and strobilurins (Group 11) were key productivity drivers. Fungicide guidelines from 1992, akin to current practices emphasised cost-effective product selection, use of the minimum necessary dosage, applying the least number of treatments, cost-effective application and timing (Cromey et al 1992).

Fungicide programmes evolved to include repeat applications, adopting a timed approach with T1 (GS 32) and T2 (GS 39) sprays, with occasional T3 (GS 59) applications if conditions were conducive to disease development.

2000s

Entering the new millennium, irrigated wheat yields rose to 12 t/ha. New chemistries were readily available and new cultivars like 'Claire' showed tolerance to many diseases, notably stripe rust. The modern T1-T2-T3 approach was well established and mixing fungicide mode of action (MoA) groups improved efficacy and became more common. Strobilurins (Group 11) such as Amistar® (a.i. azoxystrobin), Comet® (a.i. pyraclostrobin), Acanto® (a.i. picoxystrobin) and Twist® (a.i. trifloxystrobin) were used in combination with triazoles (Group 3) giving growers even greater control options.

However, the emergence of strobilurin resistance in STB in Europe in the late 1990s became widespread in the 2000s (Torriana et al 2009), foreshadowing significant change for New Zealand.

2010s

The 2010s marked a golden age of wheat production where irrigated wheat yield regularly reached 15 t/ha. Initiatives like "20 t/ha by 2020" promoted advanced sowing dates, which intensified disease pressure. Fungicides were seen as insurance against yield loss, T0 (GS 30) applications became common and susceptible cultivars, despite their vulnerability, yielded high returns on fungicide spend.

Around 2012, Septoria tritici blotch (STB) became the major disease. Much of this was due to resistance to strobilurins (Group 11), which happened in a single season (Stewart et al. 2014). Sensitivity shifts were also observed in triazoles (Group 3), which were being applied up to six times in a season, sometimes in mixtures with other triazoles.

Succinate dehydrogenase inhibitor (SDHI – Group 7) fungicides like Adexar® (a.i. fluxapyroxad and epoxiconazole, Group 7 and 3), Aviator® Xpro (a.i. bixafen and prothioconazole, Group 7 and 3) and Seguris Flexi® (a.i. isopyrazam) proved effective but carried a moderate resistance risk and were limited to two applications per season. By the early 2020s, additional SDHIs like Elatus™ Plus (a.i. benzovindiflupyr) and Vimoy® Iblon® (a.i. isoflucpyram) and Caley® Iblon® (a.i. isoflucpyram and prothioconazole (Group 7 and 3) were introduced, with some products restricted to single-use due to resistance concerns.

2020s and beyond

Wheat yields of 20 t/ha remain elusive. In the last five decades, we have had regular access to new, more effective fungicides. With increased costs and time required to bring a new active ingredient to market, we can no longer bank on the next big thing. Fungicide programmes still rely on a triazole backbone, featuring combinations of Proline® (a.i. prothioconazole), Opus® (a.i. epoxiconazole) and Revylution® (mefentrifluonazole), supplemented by other modes of action (MoAs) such as SDHIs (Group 7), multi-site (Group M4) such as Phoenix® (a.i. folpet) and the STB-specific quinone inside inhibitor (QiI - Group 21), Questar™ (a.i. fenpicoxamid). The emergence of more virulent leaf rust races has re-introduced strobilurins to wheat fungicide programmes.

Supported by 'A Lighter Touch', FAR collaborates with industry to routinely test fungicide sensitivity and develop guidelines for prolonging the effectiveness of commonly used chemistries (Table 1). Ongoing sensitivity shifts in triazoles (Figure 2) and more recently SDHIs (Figure 3) highlight the risk of pathogen resistance and the need to protect these chemistries. The days of cheap 'insurance applications' are over. Resistance management comes with a cost, but the reward is yield stability and continued access to essential chemistry in the future.

Table 1. Guidelines for use of triazole (Group 3) and SDHI (Group 7) fungicides.

Triazoles – Group 3	SDHI – Group 7
• Apply in mixtures that contain at least one other fungicide from an alternative MoA group that has comparable efficacy against the target pathogen.	• Apply SDHIs in mixtures that contain at least one other fungicide group from an alternative MoA group that has comparable efficacy against the target pathogen.
• Alternate triazole active ingredients both within and between seasons.	• Alternate SDHI active ingredients both within and between seasons.
• Use at appropriate dose to ensure effective disease control.	• Alternate mixing partners ensuring they always have efficacy against the target pathogen too.

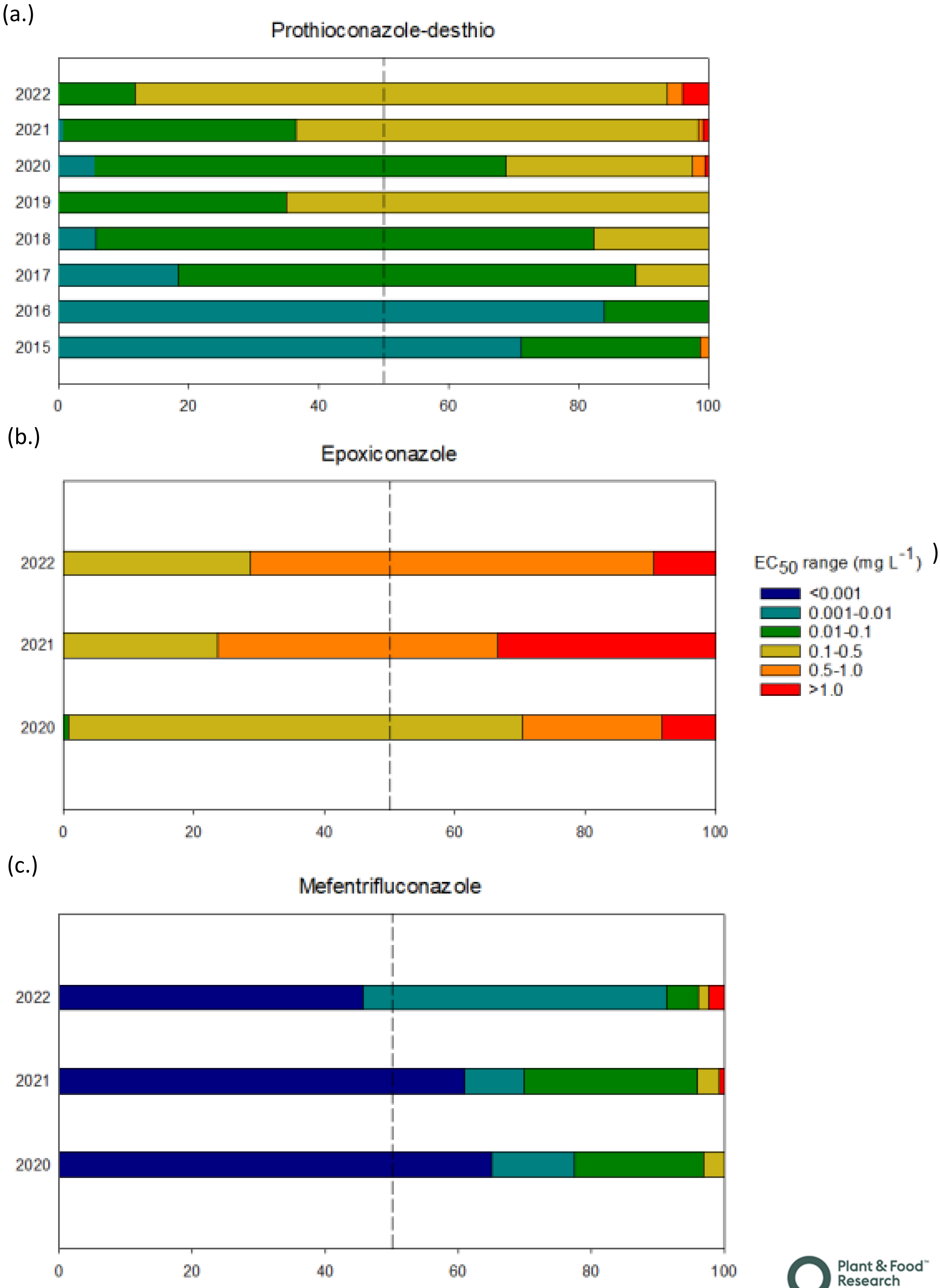

Figure 2. Comparison of percentage frequency distributions of mean EC50 (fungicide concentration that inhibits growth by 50% in mg L-1) values of *Zymoseptoria tritici* field isolates tested against the sterol demethylation inhibitors (DMI – triazoles) (a.) Prothioconazole-desthio (2015-22), (b.) Epoxiconazole (2020-22) and (c.) Mefenitrifluconazole (2020-22). Dashed line indicates 50%.

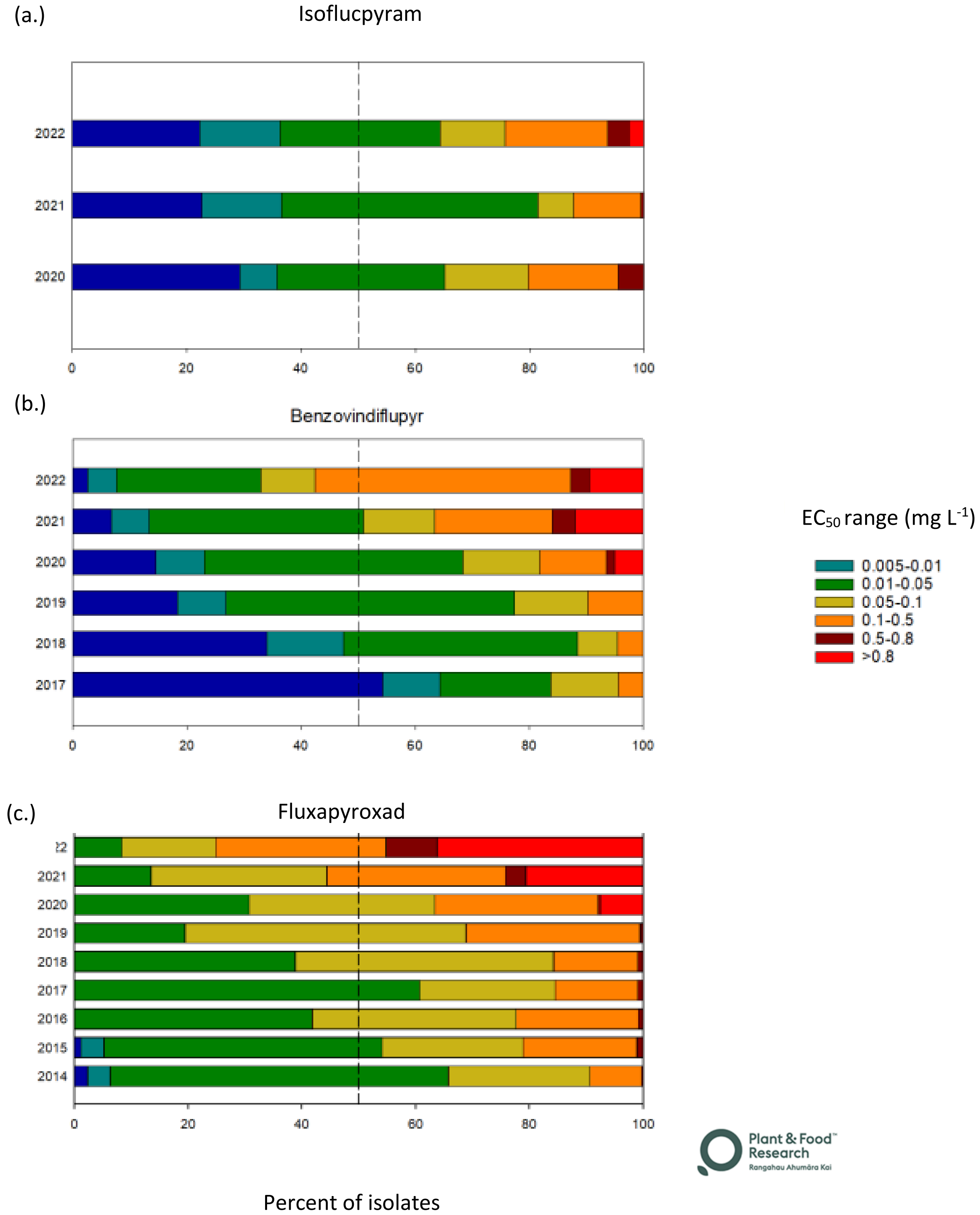

Figure 3. Comparison of percentage frequency distribution of mean EC_{50} (fungicide concentration that inhibits growth by 50% in mg L^{-1}) values of *Zymoseptoria tritici* field isolates tested from 2014 to 2022 against the succinate dehydrogenase inhibitors (SDHIs) (a.) Isoflucpyram (2020-22); (b.) benzovinflupyr (2017-2020) and (c.) fluxapyroxad (2014-22). Dashed line indicates 50%.

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This industrywide fungicide resistance initiative is supported by:

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How much grain are we leaving in the paddock?

Peter Broley & Team, Primary Sales, Australia

Quantifying via loss measurement in-field

This presentation is based on Australian research supported by GRDC and run by the Grower Group Alliance. Project details below:

- Test protocol established
- Conducted 2021 and 2022 harvests in Western Australia
- Variations (representative)
    - Crop type and variety
    - Machine/front type and style
    - Harvesting conditions

Table 1 Measurements by crop type

	Number of tests 2021	Number of tests 2022	2022 GIWA Final production est. (tonnes)
Barley	26	30	6,300,000
Canola	44	44	4,300,000
Chick Peas	10	11	Pulses 72,000
Faba Beans	18	3	
Field Peas	12	2	
Lentils	10		
Lupins	26	24	895,000
Oats	20	12	565,000
Wheat	34	30	13,930,000
Total	**200**	**156**	**26,062,000**

Table 2 Measurements by harvester brand

	Number of tests	% of test (2022)	2021 Comparison
Case IH	49	31%	31%
Claas	12	8%	10%
Gleaner	1	1%	0.5%
John Deere	77	49%	29.5%
New Holland	17	11%	26.5%
Total	**156**	**100%**	**100%**

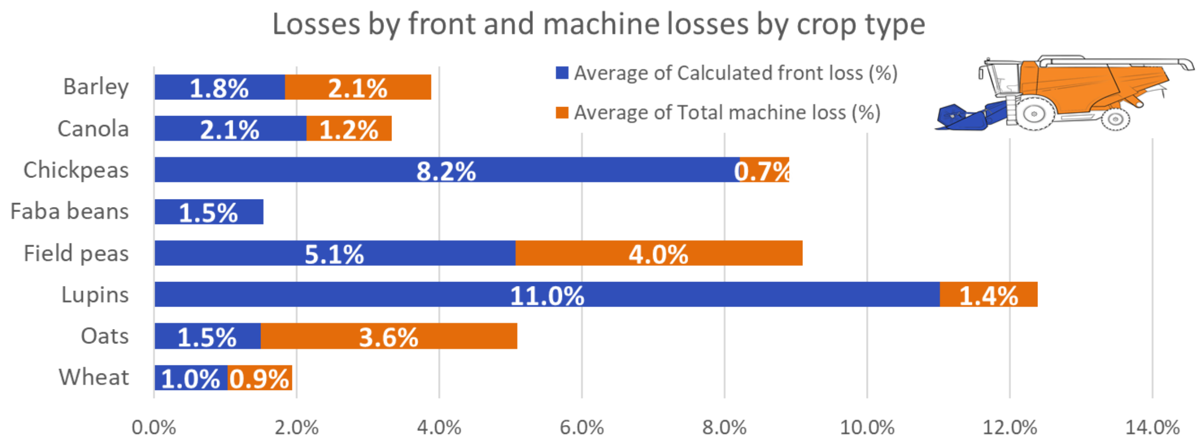

Figure 1 Losses by front and machine losses by crop type, 2022

Table 3 Average total loss in extrapolated total value terms by crop type

TOTAL EXTRAP. LOSSES	Nominal ave. Commodity price ($/t)	Average of Total Losses (%)	2022 WA production (t)	Total extrapolated value of harvest losses
Barley	$295	3.9%	6,300,000	$71,893,467
Canola	$755	3.3%	4,300,000	$109,642,448
Lupins	$345	12.3%	895,000	$37,926,702
Oats	$305	5.0%	565,000	$8,638,391
Wheat	$353	1.9%	13,930,000	$94,725,524
Total			25,990,000	$320,826,532

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