Hart long-term SEEDING SYSTEMS trial

A summary of 16 years of research

SAGIT

HART

Acknowledgements

Over the past sixteen years there have been a number of farmers, advisers and researchers who have contributed to the management and monitoring of this trial.

Matt Dare
Jack Desbiolles
G&J East
Kathy Fischer
Phil Harris
Peter Hooper
Michael Jaeschke
Brian Kirchner
Sam Kleemann
Katherine Linsell
David Maitland
Allan Mayfield
Pete & Lyell McEwin
John Nairn
Sarah Noack
Rocky River Ag
Tom & Ashley Robinson
SANTFA
Stuart Sherriff
Rochelle Wheaton
Justin & Dennis Wundke

The Hart Field-Site Group also gratefully acknowledge financial support from SAGIT who have contributed to this research for 12 years. We also thank Caring for Our Country for funding the trial during 2009 – 2012.

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Produced in August 2016

Our sincere thanks to Dr Allan Mayfield and Peter Hooper for contributing to the editing of this publication. Thanks also to Sandy Kimber for her work on communications for this project.

Disclaimer

Front and back cover photos by Sandy Kimber, 2015

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Foreword

Seeding systems are an integral part of any modern farm and choosing the right system has implications in terms of financial outlay and production.

In the year 2000 the Hart Field-Site Group purchased their own land and saw the opportunity to set up a commercial scale, long-term trial focusing on the then current and newer seeding systems.

Sixteen crops later, this trial has remained one of the most popular in our program. Having long-term farmer sown treatments allows other farmers to make more informed decisions when choosing a seeding system which can be a large capital purchase.

Having sown the no-till treatments a number of times, I have not only found value in looking at the yield data but also the changes in soil available nitrogen over time.

The overall message from the trial has been a good one, in that there is no one seeding systems that gives consistently higher yields.

The decision on which seeder to purchase has to be for other reasons such as weed and pest management in addition to soil type, stubble handling or increased speed of sowing.

I encourage all farmers to use this publication, including and the farmer stories featured at the end to help make more informed decisions regarding their seeding system.

Justin Wundke
Condowie farmer and Hart Field-Site Group vice chairman

Above: Hart vice-chairman Justin Wundke seeding the ‘no-till’ treatment in the seeding systems trial, 2013. His seeder setup is a 33 ft Horwood Bagshaw knife-point press wheel system.

Background

This section has been complied with the assistance of Dr Allan Mayfield, previous Hart Field-Site Group trials manager and key member in the development of the seeding systems trial.

Why do the trial?

A major shift in seeding systems

In 1995 after a series of favorable seasons and good economic returns, many farmers in the area were in a position to upgrade their seeding equipment. There was a big focus on direct drill air seeders (one pass systems, either knife-point or disc), with only a handful of farmers in the area using them. Over the next four years there was a rapid adoption of direct drill seeding systems before the trial started.

In general the majority of farmers wanted to adopt direct drill systems to reduce the risk of soil erosion and improve the timeliness of seeding. Erosion wasn't a big driver at Hart due to the soil type, however, it was an issue in areas with soils prone to erosion. The quickest uptake of direct drilling was further inland to the east, in areas with hard setting soils and cooler soil temperatures. In some years with a heavy rain after sowing, parts of the paddock would crust over and the crop emerged poorly. Once they started direct drilling with knife-points and press wheels they never had that issue again. These farmers were also keen to use a deeper point which fractured the soil below the seed, in harder setting soils. This produced a better crop establishment.

Left to right: Seeding systems trial sown to durum wheat in 2006; disc treatment by Greg Butler, SANTFA, no-till treatment by Matt Dare, strategic treatment by Michael Jaeschke.

It was this combination of soil issues and erosion control that was the real driving force for some farmers. For others the move to no-till or zero-till was simply for operational efficiency. That is, instead of a pre-working cultivation to incorporate urea, they went seeding. It was through direct drilling that they were able to bring their sowing date forward to a more optimal time. This system also improved crop safety with some of the soil incorporated herbicides, such as trifluralin.

Disc seeding systems were uncommon then. In the early days, planning the trial included only knife-point (no-till) and strategic tillage (cultivation, burning and wide points) treatments. Hart board member, then chairman and Bute farmer, Phil Harris, was the main advocate for the disc treatment remarking "Nah, you've got to have a disc, it's the next big thing, I'll bring it across". For the first five years of the trial Phil drove his disc seeder from Bute to Hart, over 50 km away.

Resulting research questions

In the initial days of direct drilling, farmers and agronomists observed poor crop vigor if one or more nutrients were limiting, in particular zinc. This was explained by the fact that zinc is not readily mobile in soil and does not move far from where it is applied in the fertiliser granule. Less soil disturbance in no-till and zero-till systems meant nutrients like zinc were not mixed throughout the topsoil, but left in concentrated bands where they were applied at the time of application.

The zinc issue was addressed through additional zinc fertiliser applications and is part of the reason why a two-tiered nutrition treatment was established in the trial. There was also evidence that in harder settings soils, where it is colder, early direct drilled crops were slower in early crop growth. These observations formed some of the key questions to be investigated in the seeding systems trial:

- Was there a nutritional penalty in direct drilled systems?
- Could this problem be fixed by adding additional nutrients?
- How long did it last for and did it make any difference in terms of yield?

Direct drilling also meant a significant shift in the way nitrogen was applied. In conventional systems it had been common practice to apply nitrogen fertiliser in a pre-sowing cultivation. The additional nitrogen treatments in the Hart trial were to address the question that if crops were slower earlier, would the addition of extra nitrogen fix it. In short, no nutritional deficiencies were detected in direct drilled crops at Hart compared to conventional systems, as the soil already had adequate nutrition. Neither was the crop slower in those early years which may have been due to the location of the site. If the trial site was further inland where it was colder, there may have been an effect. The nutritional treatments became more of a monitoring tool for longer term effects over time.

All systems go – preparing to sow the trial in 2007

How has the trial evolved to keep up with seeding systems?

Since the development of the trial, the no-till treatment has not changed significantly. It is still a knife-point and press wheel system relevant to farmers, but the discs have changed a lot; throughout the trial different disc systems have been used due to machine proximity to the trial site and changes in disc seeder setups. Many Hart member's felt the direct drill treatments (disc and knife-point) should be sown earlier as that was best practice however, that would have immediately confounded the results.

The most significant change to the trial design has been the inclusion of stripper front straw in the disc treatment. This change was designed to replicate the evolution of stubble management for disc seeding systems and started in 2013.

Trial setup

The trial consists of three seeding systems (combination of seeder type, cultivation and stubble management) and two nutrition regimes replicated at the Hart field site.

Seeding systems

1. Strategic – often worked up pre-seeding, sown with 100 mm (4 inch) wide points at 200 mm (8 inch) row spacing with finger harrows. For the past 16 seasons this trial has been sown by farmer Michael Jaeschke (farmer story pg 26)
2. No-till – sown into standing stubble in one pass with a Flexicoil 5000 drill, 16 mm knife-points with 254 mm (9 inch) row spacing and press wheels. This treatment has been sown by a number of seeders and is the most common setup around Hart (farmer story pg 18).
3. Disc – sown into standing stripper front stubble with John Deere 1980 single discs with row spacings of 152 mm (6 inch), closer wheels and press wheels. This treatment has been sown by Tom and Ashly Robinson for the past four season (farmer story pg 20).

While there have been slight modifications to the trial, the core principles of these three seeding systems have remained. Since 2013, the disc treatment has been harvested with a stripper front to represent the next step in stubble management and disc seeding occurring in the area. Each seeding system results in a different level of soil disturbance (Figure 1) and stubble retention.

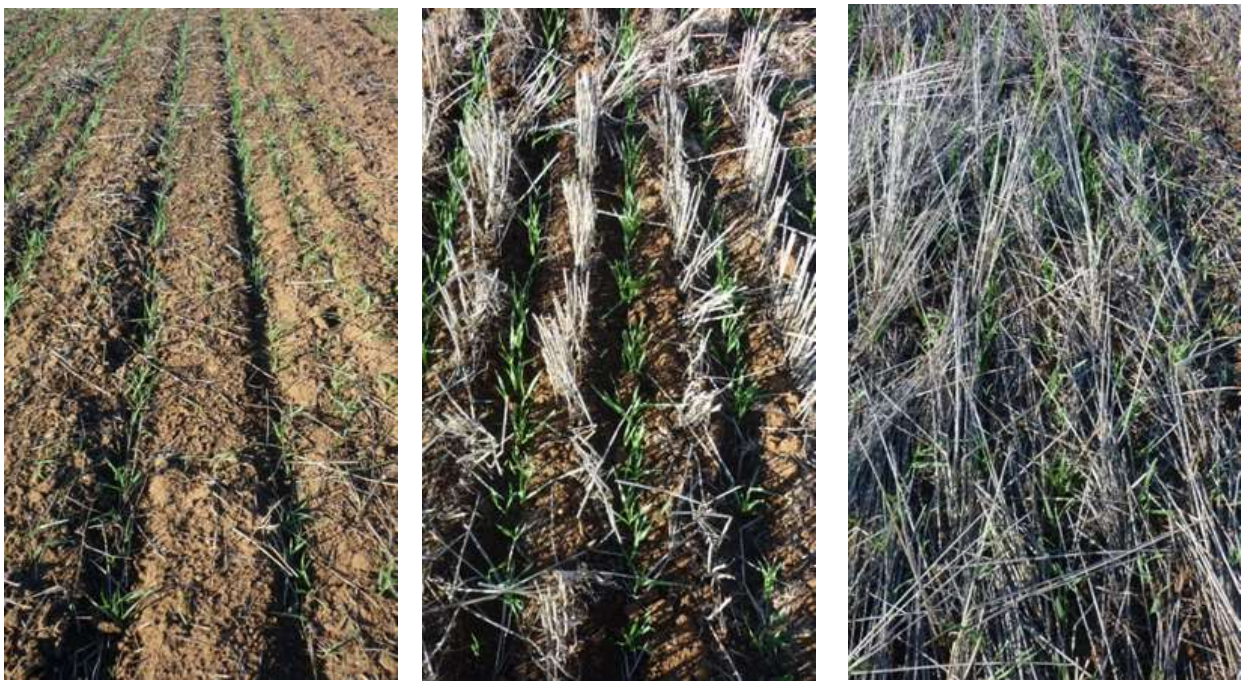

Figure 1. (Left to right) Commander barley sown in the strategic treatment, no-till treatment sown into 30 cm standing stubble and the disc seeder into stripper front stubble (70 cm tall), on 18th June, 2014.

Two **nutrition treatments** were based on varying applications of nitrogen and the addition of the micronutrient zinc.

1. **medium nutrition** treatments represent standard practice nitrogen for the district based on Yield Prophet® and general rules of thumb.
2. **high nutrition** treatment represents standard district practice plus an additional nitrogen application in season (generally 20-50 kg N/ha additional).

Crop rotation

2000	2001	2002	2003	2004	2005	2006	2007
Sloop barley	ATR-Hyden canola TT	Janz wheat	Yitpi wheat	Sloop barley	Kaspa peas	Kalka durum	Janz wheat

2008	2009	2010	2011	2012	2013	2014	2015
Janz wheat	Flagship barley	Clearfield canola	Correll wheat	Gunyah peas	Cobra wheat	Commander barley	44Y89 (CL) canola

Site information

Rainfall

The long-term average annual and growing season rainfalls for Hart are 400 mm and 305 mm respectively. Seven of the past 16 seasons of this trial have been tested with above average rainfall (Figure 2). The remaining nine seasons were below average, particularly in the mid-2000s when the district experienced consecutive dry seasons.

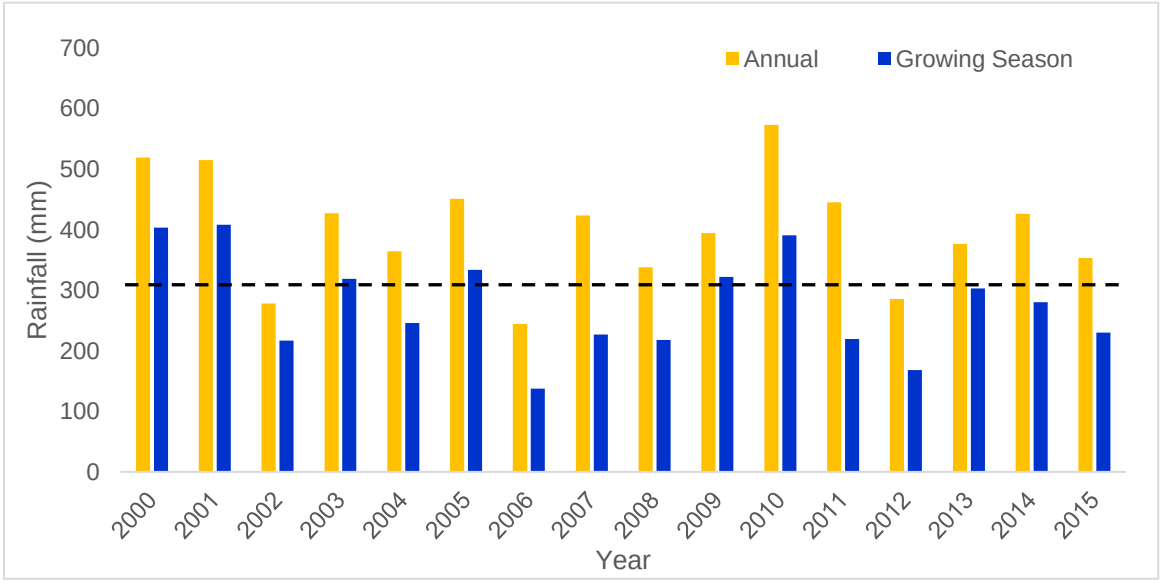

Figure 2. Hart annual and growing season (April – October) rainfall (mm) from 2000-2015. The long-term average growing season rainfall for Hart, 305 mm, is represented by the dashed black line.

Soil Type

Clay loam grading to calcareous and dispersive clay subsoil (Table 1).

Table 1. Long-term seeding systems trial soil profile description.

Horizon	Depth (cm)	Description
A11p	0–8	Dark reddish brown, heavy clay loam with moderate structure
A12	8–22	Moderately calcareous, dark reddish brown and yellowish red, light clay with weak structure
B1	22–36	Highly calcareous, reddish brown, medium clay with moderate structure and 10–20% fine carbonate segregations
B2k	36–65	Highly calcareous, slightly dispersive, reddish brown, medium clay with 20–50% fine carbonate segregations
B3	65–96	Highly calcareous, slightly dispersive, reddish brown, medium clay

Summary

The overall outcome from the seeding systems trials has been a good one for farmers. No particular system or nutrition regime has given a consistently higher yield which means that the decision about which seeding system to use has to be for other reasons, such as weed and pest management, speed of sowing or stubble management. This result is reflected across the southern region, where a large variation now exists in stubble management and seeding strategies. The following section provides a summary of various crop, weed and soil measurements taken in the seeding systems trial or related research.

What do the results say?

Grain yield and quality

One of the main outcomes from this trial has been the lack of consistent performance in terms of grain yield from any one particular seeding system. In ten out of 16 seasons there has been no significant difference in grain yield among any of the seeding systems (Table 2). For the other six seasons, the highest yields varied between seeding systems and were not consistent. In seasons where yield differences were observed, growing season rainfall was low and the no-till and disc alone or together outperformed the strategic treatment.

Table 2. Grain yield (t/ha) for seeding systems and nutrient treatments from 2000-2015.

		Strategic		No-till		Disc		LSD (P≤0.05)		
Year	Crop	Medium	High	Medium	High	Medium	High	seeder	nutrition	seeder × nutrition
2000	Barley	3.8	3.8	3.7	3.8	3.7	3.9			
2001	Canola	1.3	1.6	1.4	1.7	1.3	1.8	ns	0.1	ns
2002	Wheat	0.9	0.7	0.9	0.8	0.7	0.6	ns	ns	ns
2003	Wheat	2.8	2.6	3.0	3.0	3.1	3.2	0.3	ns	ns
2004	Barley	2.3	2.0	2.1	2.1	2.0	1.7			0.3
2005	Peas	2.5	2.6	2.4	2.3	2.1	2.1	0.2	ns	ns
2006	Durum	0.1	0.1	0.2	0.2	0.1	0.1	ns	ns	ns
2007	Wheat	1.9	2.2	2.3	2.1	2.3	2.4	ns	ns	ns
2008	Wheat	1.1	0.8	1.3	1.2	1.5	1.4	0.2	ns	ns
2009	Barley	4.3		4.2		4.2		ns	ns	ns
2010	Canola	1.2	1.9	1.5	2.0	1.6	1.9			0.3
2011	Wheat	2.3	2.2	2.5	2.5	1.7	1.8	0.2	ns	ns
2012	Peas	0.9	0.9	1.1	1.1	1.1	1.0	0.1	ns	ns
2013	Wheat	-	-	5.0	5.0	5.2	4.8	ns	ns	ns
2014	Barley	4.4	3.9	4.7	4.0	4.5	4.0	ns	0.2	ns
2015	Canola	0.6	0.6	0.6	0.5	0.5	0.5	ns	ns	ns

Similarly, the seeding system used has had little impact on grain protein (Table 3), screenings or test weight (Appendix 1) across the history of the trial. The additional nitrogen treatments however resulted in higher protein in half of the cereal phase years (Table 3). Grain protein is influenced by a range of factors including rainfall, grain yield and starting available soil nitrogen. Where a protein level increase was observed, it resulted in a receival standard difference of delivering H2 or APW to obtaining H1 (>13%) classification. In two out of three canola crops, the higher nitrogen rate resulted in a small but significant reduction in oil content (Table 3).

Table 3. Grain protein or oil content (%) for nutrient treatments (averaged across all three seeding systems) from 2000-2015.

	2000	2001*	2002	2003	2004	2005	2006	2007
Medium	10.6	39.7	11.7	10.9	12.9	*field pea*	14.7	13.1
High	12.1	38.0	12.0	12.8	16.4		14.8	13.2
LSD (P≤0.05)		**0.7**	**ns**	**1.5**	**1.4**		**ns**	**ns**

	2008	2009	2010*	2011	2012	2013	2014	2015*
Medium	15.5	10.8	42.8	10.2	*field pea*	12.6	12.0	36.3
High	17.2	11.4	42.1	12.7		13.9	14.3	35.7
LSD (P≤0.05)	**1.1**	**0.4**	**0.4**	**0.5**		**0.6**	**0.8**	**ns**

*indicates canola oil content (%)

Available soil nitrogen

An increase in available soil nitrogen has often been observed in the high nutrition treatment (Figure 3). In general, the difference between the high and medium nutrition treatment has ranged from 4 to 50 kg N/ha at the start of each season. This is not surprising, as over the last 16 years an additional 375 kg N/ha has been applied to the higher nutrition treatment. This additional nitrogen would have entered a number of pools including the grain, bound to soil particles and incorporated into soil organic matter. The higher amount of nitrogen in this treatment means there is additional soil nitrogen to break down carbon rich stubble, which results in faster mineralisation rates.

In many seasons no difference in starting soil N was observed. This can be attributed to a number of factors that influence mineralisation (and therefore available soil nitrogen) such as summer rainfall, stubble type (cereal, canola or legume) and stubble placement.

Seeding system has had little impact on starting available soil nitrogen. In general, the disc and no-till treatments have produced similar results over the life of the trial. This is also reflected in the fact that grain yield and protein are similar for these treatments. However, in a small proportion (25%) of seasons, the strategic treatment has had a higher available nitrogen pre-seeding (Figure 3). This can be attributed to the placement of stubble in this treatment which influences decomposition and mineralisation rates in combination with increased soil mixing. The surface placement (eg. no-till and disc) of stubble results in slower decomposition rates compare to the strategic treatment which is often cultivated pre-seeding or prickled chained, incorporating stubble into the topsoil.

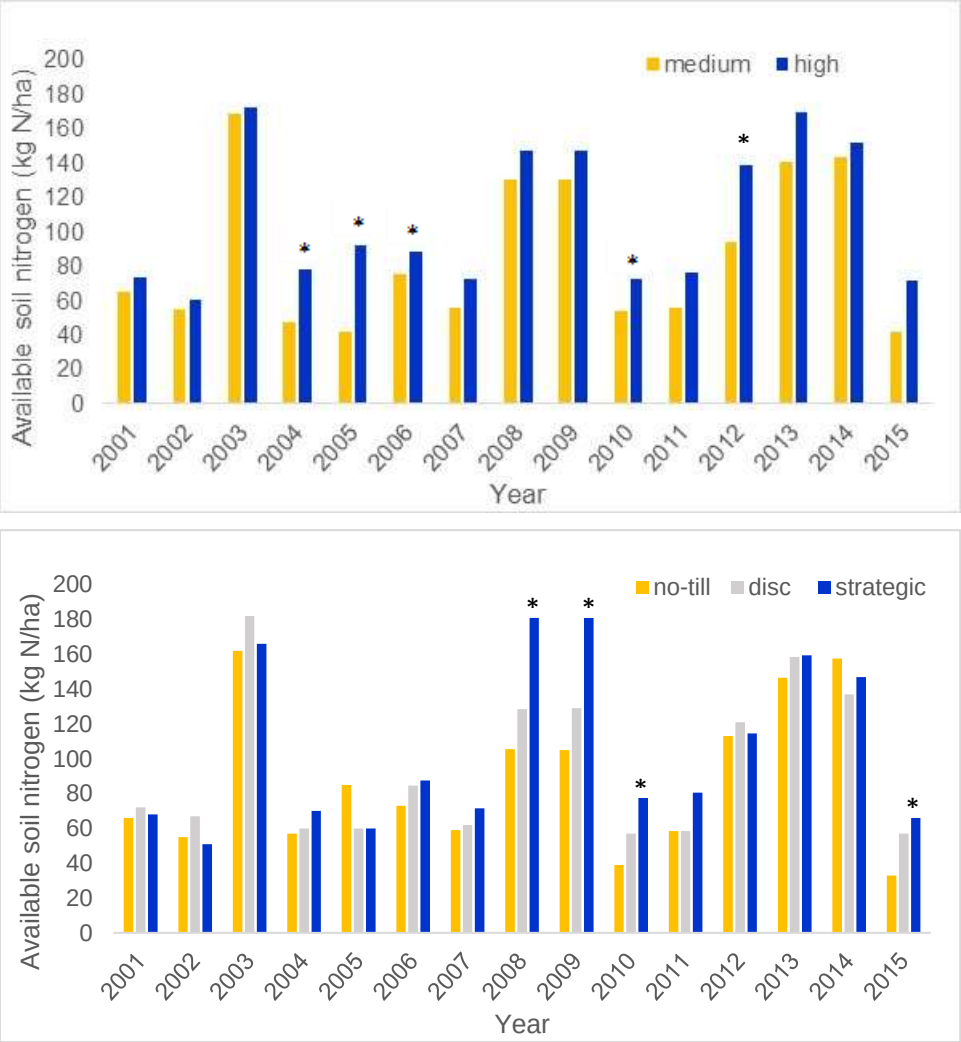

Figure 3. Summary of soil available nitrogen pre-seeding in (top) nutrition treatments and (bottom) seeding systems 2001-2015. Bars appended with an asterisk are significantly different (P≤0.05) for the treatments in that year.

Soil organic carbon

Soils contain large amounts of carbon in both organic and inorganic forms. Soil organic carbon (SOC) is found in soils in the form of various organic compounds, commonly called soil organic matter. Long-term trials have shown a reduction in tillage, and therefore soil disturbance, results in increased SOC levels (Sanderman et al. 2009). An increase in soil organic carbon improves soil structure and other physical, chemical and biological soil properties.

In 2007 and 2014, SOC levels were assessed in the seeding systems trial. The SOC levels ranged from 1.65% to 1.78% in 2007 and 1.57% to 2.18% in 2014. The average difference between the two sampling years (seven years) was 0.2% (Table 4). In comparison, the native vegetation area at the site contained 5.20% (data not shown) SOC in 2014.

The data showed that despite differences in soil disturbance and therefore decomposition in both sampling years there was no significant difference between seeding system or nutrition. Currently, there is much debate as to the total potential of agricultural soils to store additional carbon, the rate at which soils can accumulate carbon and how best to monitor changes in SOC stocks (Sanderman et al. 2009). Many trials and paddocks monitored and sequestration rates were found to diminish with increasing trial duration. The authors found that largest gains in SOC were generally found within the first five to ten years with the rate of change diminishing to nearly zero after 40 years.

Table 4. Soil organic carbon (%) levels in seeding systems and nutrition levels measured at Hart in 2007 and 2014.

Seeding system	Nutrition	SOC %	
		2007	2014
Strategic	Medium	1.69	1.98
Strategic	High	1.75	1.99
No-till	Medium	1.65	1.57
No-till	High	1.78	1.89
Disc	Medium	1.70	1.97
Disc	High	1.75	2.18
LSD (P≤0.05)		ns	ns

Weeds and pests

Weed spectrum change without tillage

Differences between seeding systems, such as tillage and residue levels, affect the microenvironment around weed seeds, for example light exposure and temperature, as well as the vertical distribution of the seeds in the soil. This vertical distribution has been shown to effect the dormancy of and therefore ability of weed seeds to germinate. In local studies at Roseworthy and Minlaton, Chauhan *et al.* (2006) found that ryegrass seed in no-till systems, which tended to accumulate on the soil surface, was less inclined & slower to germinate due to adverse germination conditions (top soil drying out quicker). Seed which failed to germinate was also more vulnerable to predation by insects such as ants.

In this study the authors looked at germination behavior of ten different weed species common to the wheat belt of southern Australia under both minimum tillage & no-till. Weed species that prefer soil disturbance and burial with minimum tillage system (two cultivation passes pre-seeding) included annual ryegrass, threehorn bedstraw and wild radish. In contrast, the germination of Indian hedge mustard, sowthistle, silver grass, marshmallow and turnip weed was higher under no-till system. The germination of wild oats and wild mustard was not influenced by either minimum or no-till seeding systems.

These differences were primarily due to the ability of the weeds to germinate on or near the soil surface. Small seeded species often require light for germination and are favored under no-till, whereas large seeded species have lower dependence on light and have greater energy reserves from the seed for deeper germination under conventional or minimum tillage. However, a consequence of deeper burial is that these weed seedlings can take longer to emerge and are generally less vigorous, which can sometimes reduce their competitiveness with crops.

Weed observations in the trial

The trial has been managed to eliminate the effects of weeds however, in some seasons weed escapes have been observed. In 2009 there were significant differences in the brome grass and annual ryegrass populations across the seeding treatments. *Brome diandrus* populations were high in the early sown no-till plots at 71 plants/m^2 in the following season (Table 5). Part of the no-till treatment was early sown in 2007 and 2008. The population spike in the following season can be attributed to the previous dry sowing or sowing prior to weed emergence.

Table 5. Grass weed populations (plants/m^2) in the seeding systems trial at Hart, 2009 averaged across the nutrition treatments.

Seeding system	Brome grass	Annual ryegrass	Wild oats
	Plants per square metre		
Disc	14	19	10
Strategic	26	137	0
No-till	29	79	16
No-till (early)	71	92	28
LSD (P≤0.1)	33	84	ns

The disc treatment had the lowest level of brome grass however, this is not reflective of field observations. Anecdotal farmer evidence suggests brome grass is becoming an increasing issue in no-till systems, particularly in disc seeding systems (example farmer story 4, pg 24). The prevalence of brome grass has increased through more intensive cropping with few effective in-crop herbicide options, adoption of no-till where brome seeds are only buried at seeding and so emerge later in the crop's growth.

The highest rate of brome germination has been shown to occur if seeds are buried within 50 -100 mm of the soil surface. Therefore, in the no-till systems, where seeds are generally close to the soil surface, most surviving seeds will germinate in the year after seed production. Furthermore, brome grass germination is inhibited by light; that is, seed placement too close or on the soil surface will inhibit germination (Kleemann and Gill 2009). In zero-till (disc) systems, where this is little soil throw, seeds can be left undisturbed on the surface and will not germinate until covered (eg. by crop residue) which is likely to be later in the season and harder to control leading to weed escapes.

Pre-emergent herbicide selection and crop safety

There are a range of free resources available on pre-emergent herbicide crop safety and weed control in different seeding systems;

- Using pre-emergent herbicides in conservation farming system (2012) NSW DPI
- Disc seeders and pre-emergence herbicides (2013) GRDC Updates
- Influence of seeding systems and stubble management on pre-emergent herbicides (2015) Hart Field Site Group Trial Results

The results for annual ryegrass were more reflective of farmer paddocks. The highest levels of ryegrass were contained in the strategic (137 plants/m^2) and no-till (86 plants/m^2) treatments. As observed by Chauan et al. (2006) ryegrass is a smaller seeded weed species and germination is favoured by light and tillage to create optimal germination conditions. In contrast the low disturbance disc treatment contained the lowest ryegrass population.

The average wild oat density in the seeding systems trial was 13 plants/m^2 and there was no significant difference among the treatments. The is in line with the study of Chauhan et al. (2006) who found the germination of wild oats was not influenced by either minimum or no-till seeding systems.

Pest observations in the trial

Similar to the weed surveillance, the trial has been managed to reduce pest pressure however, both snail and mice damage has been evident. For example, in 2001 round snail damage was greatest in the disc and no-till treatments with an average of 20 and 34% of plants containing snails compared to 7% in the strategic treatment (Table 6). Generally, the retention of stubble and lower disturbance creates favorable habitats for pests like snails compared to slashing, burning and prickle chaining. Over summer the snails remain dormant on any objects they can find above the soil surface, such as stubble (Figure 4) to avoid the hot soil temperatures.

Table 6. Summary of the snails present on canola plants (%) in the seeding systems trial at Hart, scored 30th of November 2001.

Seeding system	Nutrition		*Average*
	Medium	High	
Strategic	7	7	*7*
Disc	28	13	*21*
No-till	30	37	*34*
LSD (P≤0.05) seeder			20

More recently in 2015, snail damage was observed in the trial when sown to canola. Similar to 2001 snail populations were highest in the standing stubble treatments causing plant damage and patchy crop establishment. Snail populations were also present at harvest and plots were cut high to prevent intake of snails, which would have required seed cleaning if delivered.

Figure 4. Round snails taking refuge from the hot summer soil temperatures on stripper front stubble (left) and in crop/stubble at harvest (right), taken at Hart.

The shift to no-till has also contributed to increased mouse activity in southern Australia. Mouse burrows have been observed in the current trial, and are more evident in the high stubble and lower disturbance treatments. There has been considerable work in this area which has shown there are a number of factors in our modern cropping systems which contribute to increased mouse numbers and activity (Mutze 2014):

- Adoption of no till – less burrow disturbance and shelter from standing stubble.
- Reduction in livestock - less competition for seeds and lower burrow disturbance from stubble grazing.
- New crops - more high quality food available
- Shallower seeding depths - easier access to sown seeds

Combined these factors has resulted in more cover, undisturbed burrows and more food available for mice. Monitoring and a sound management plan in place are important for making these systems work.

Third year agricultural science students from the University of Adelaide taking crop measurements at Hart in August 2016. The long term nature of the seeding systems trial provides an opportunity for students to link theory with practice.

"It's vitally important for our third year students, who will be working in the industry next year, to visit a site like Hart to look at some of the leading questions farmers need addressed through research."
Dr Gurjeet Gill, University of Adelaide

Soil biology and seeding systems

In the last decade there have been a number of molecular tools developed to increase the speed and diversity of soil microorganisms measured in soil. Currently, SARDIs molecular diagnostic center are looking at the effects of different management practices on free living nematode communities. Unlike parasitic nematodes (cause damage to crops), free living nematodes have the potential to act as indicators of soil health.

Across a range of management factors investigated, Linsell *et al.* (2014) found nutrient additions (nitrogen, phosphorus, potassium and sulphur) were a key driver of nematode differences, followed by environment (soil type and rainfall), rotation, organic matter and tillage.

The analysis of tillage showed two distinct free living nematode communities under no-till and tillage systems (Linsell *et al*. 2014). The conventionally cultivated soils had more plant parasitic nematode, *Pratylenchus*, and also bacterial feeding nematodes. The no-till community was characterised by fungal feeding nematodes and the large omnivorous nematode, *Eudorylaimus,* indicating a more structured community which may be expected with less disturbance. The no-till soils had higher organic C and generally higher yields which may explain the fungal dominance as there would be more organic matter retained on the surface than conventionally tilled soils, which would be largely decomposed by fungi.

In 2012 and 2013 the Hart seeding system trial was sampled as part of this study. The main findings from the results were:

- Disc treatments were dominated by more fungi compared to bacteria. The no-till treatment also contained fungi but in addition, more bacterial opportunists.
- The fungal pathogen, crown rot (*Fusarium pseudograminearum)*, was the main driver of this seeding system effect.
- Crown rot inoculum was more abundant in the disc than no-till treatments. The levels of this pathogen were very high and fell into the high disease risk category as determined by PreDictaB ratings.
- A similar trend was observed for stem nematode (*Ditylenchus dipsici)*, which was also more abundant in disc seeded plots.
- The data suggests no-till treatments may encounter lower populations of both crown rot and stem nematode as there is greater disturbance of both soil and stubble during sowing.

Economics

A partial gross margin analysis was conducted from 2000-2008 to assess the impact of seeding systems and fertiliser rate. This analysis takes into account differences in grain yields, fuel use, labour use and depreciation on the capital items for an area of 1500 ha. Weed control, disease control and grain quality were all considered the same.

The analysis showed small differences among the treatments (Figure 5). In this period the no-till seeding system provided the highest cumulative margin and combined with the lower input level the best financial outcome. The no-till treatment at medium nutrition was $200/ha above the disc and strategic which over eight years can be expressed as $22/ha per year. It was not surprising that the lower fertiliser input level proved to be the best, as the average growing season rainfall during the trial period was a low decile 3. Generally, the best economic results in poorer seasons occur from low input strategies.

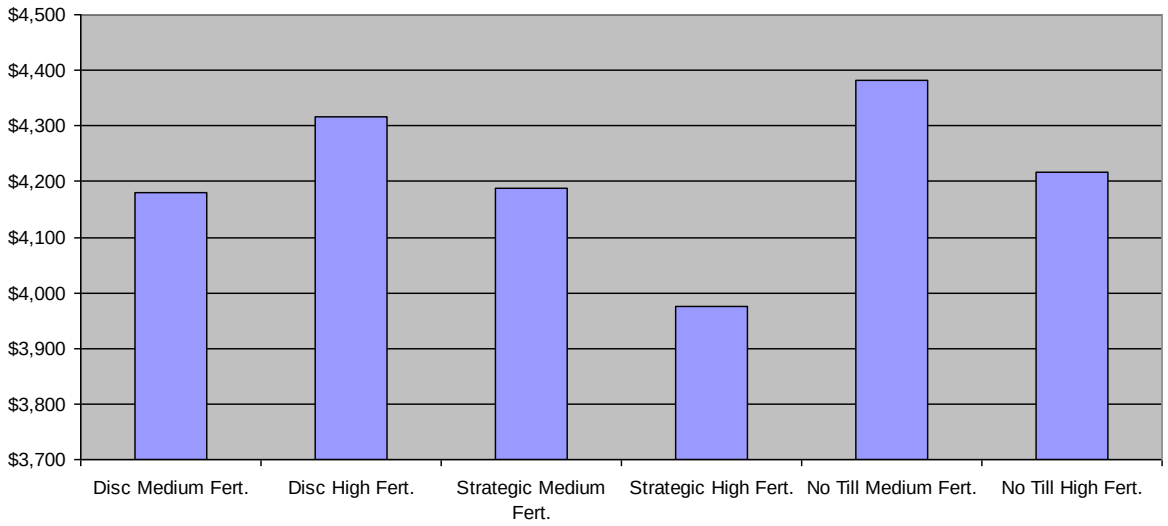

Figure 5. Cumulative partial gross margin ($/ha cumulative) results for seeding systems and nutrition rate from 2000 – 2008. *Krause, Applied Economic Solutions.*

Although the cumulative gross margins between the treatments are similar there are differences which were unable to be measured.

- The no-till and disc seeding systems offer farmers greater labour efficiency compared to the strategic system. The gross margins do allow for labour, however, sourcing and maintaining it can be difficult, which may impact on a strategic approach.
- These systems also offer the potential for improved time of sowing, being able to sow into marginal soil moisture and using only one pass.
- As farms continue to get bigger the ability to sow quicker becomes more important, and is where disc seeders might have a big advantage.
- Strategic cultivation in the strategic treatment means that the reliance on herbicides for pre-sowing and summer weed control is much less.

Experience and comparison of seeding systems on farm

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A flexible seeding system
Matt Dare, Marola

Farmer Story 2 Pg 20
Full stubble retention and maximum soil cover
Tom Robinson, Hoyleton

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Andrew Sargent, Crystal Brook

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Simplicity seeding
Michael Jaeschke, Hart

Farmer story 1

A flexible seeding system

Farmer	Matt Dare
Location	Marola
Property size	840 ha
Rainfall	470 mm annual 350 mm growing season
Soil type	Red loam & brown cracking clay
Enterprise	100% seeding cereals, legumes, canola and oaten hay
Seeder	Flexicoil 5000 bar 16 mm knife points with 10 inch row spacing and press wheels

Marola farmer Matt Dare has been utilising a no-till seeding system for 15 years. His shift and continued use of a knife-point press wheel seeder has been attributed to the flexibility of the system and a combination of being able to retain stubble, reduce erosion, minimise weed stimulation, along with more timely sowing operations.

Matt purchased his Flexicoil 5000 bar in 2012 and describes his unit as flexible and simple. The system runs on 250 mm row spacing with inter-row sowing facilitated by 2 cm RTK auto-steer. An average sowing speed of 8 km/h is achieved. 'We went from walking press wheels on our old Flexicoil 820 which was fine, but with our current seeder there's a lot more weight on the press wheels. We have castor wheels on the front and we don't have any wheels within the frame to improve trash flow. We have a row of press wheels at the back and they take the majority of the bar weight. There is a lot more pressure in the furrow and in our soils that is fine, but for hard setting soils that can be an issue.'

Marola farmer Matt Dare has been using a no-till seeding system for 15 years.

A crop rotation of wheat, wheat, oaten hay, canola, wheat, barley and legume is used with oaten hay grown to assist with weed control.

The main weeds on Matt's property are ryegrass, wild oats and bifora although he has found no-till has improved his weed control. His shift to no-till has decreased weed seed burial, enabled an earlier time of sowing, increased crop competition and increased the flexibility of chemical rates and application timing.

Other seeding problems include sticky soils that encourages legume stubbles to wrap around press wheels and vine type summer weeds (such as wire weed, caltrop & melons) wrapping around tines. This has increased the importance of summer weed control.

Matt Dare's shift and continued use of a knife-point press wheel seeder has been attributed to the flexibility of the system and a combination of being able to retain stubble, reduce erosion, minimise weed stimulation, along with more timely sowing operations.

Matt says the only modification he has made to his system as a whole is more timely summer weed control. More recently, when it came to purchasing a new seed cart Matt was specifically looking for something with 2 m wheel spacing to follow his tram lines and reduce compaction.

At this stage upgrading his seeding system is not on the immediate agenda, but Matt is keen to see how the disc technology comes along. 'We actually do all of our stubble management with our header whereas other people running discs can't put too much trash through the header which is where stripper front harvesters have come into play. For me disc seeding systems are a bit inflexible at the moment and machinery isn't my strength, I'd rather have something simple.'

In terms of the seeding systems trial at Hart, for Matt the results have showed that there is no yield difference between the seeding systems as some people perceive. 'I think it's more around timeliness of sowing and how it works within your whole operation. It's good to see the discussion that's resulted as part of the trial. Doing something on the site with farm scale machinery keeps it relevant for farmers.'

Farmer story 2

Full stubble retention and maximum soil cover

Farmer	Tom Robinson
Location	Hoyelton
Property size	1620 ha
Rainfall	420 mm annual 380 mm growing season
Soil type	Red brown clay loam
Enterprise	100% seeding cereals, canola and some cover seeding (sunflowers & sorghum)
Seeder	John Deere 1980 single disc at 6 inch row spacing, closer wheels and press wheels

Along with his father Ashley, Tom Robinson has been using a disc seeding system since 2003. The Robinson's have been using a one pass seeding system since 1992 with their previous seeder having a prickle chain attached to the back of it. Their reasoning behind shifting to a disc system was because they wanted to retain as much stubble as they could and maintain that level of stubble.

The Robinson's purchased their 1890 John Deere single disc in 2003 and the system consists of 6 inch row spacing, RTK guidance and a sowing speed of 8-12 km/h. Tom says the biggest change to their system has been the purchase of a stripper front harvester. Their disc seeder allows them to retain high amounts of stubble and still be able to sow their crop without reduced establishment.

Tom Robinson, Hoyleton, says the biggest change to their system has been the purchase of a stripper front harvester.

Currently the Robinson's utilise a crop rotation of wheat two to three times in a row, followed by canola or a bean crop depending on the paddock's need and weed burden. Recently their interest has been into companion seeding to improve their ground cover and diversity. "That's probably the main thing I think we are lacking in our system, diversity. At this stage I can't come up with a stable pulse rotation that is going to give us the groundcover that we want which is why we've looked into summer seeding."

To decrease their weed burden the Robinson's utilise narrower row spacing, varieties that are more competitive and rotating their herbicides. Their main focus is on crop competition. "Crop competition is the most underutilised "*herbicide"* that we have. We aim for good competitive plants and try to get them all up on the same day." Tom says that although their choice in herbicides is limited, it has not impacted the level of weed control they can achieve. "All our weeds are on the soil surface, we don't have shoots coming through the soil which is why we are finding things like Sakura® and Boxer Gold® good for weed control as they are root uptake herbicides."

Most of the problems the Robinson's have faced with their seeding system have been managed with modifications. "We have made a lot of modifications to the seeder in terms of upgrading different equipment, but all of it has been changed for a reason." Fertiliser toxicity has been a problem but Tom says it has been a good thing as it has led them to think about dropping their early fertiliser rates.

> "Crop competition is the most under-utilised 'herbicide' that we have. We aim for good competitive plants and try to get them all up on the same day." **Tom Robinson**

Some people may argue disc seeding system requires more maintenance, but for the Robinson's they have found regular maintenance has decreased their machinery running costs. "We don't have any livestock and the maintenance I do on our machine reduces the time spent elsewhere. We don't do slashing, prickle chaining or any other labour intense practices like that. Basically we've only got two machines running at seeding time, the sprayer and seeder."

Looking towards the future, Tom thinks that a new purchase will likely occur within the next 10 years. "We'd be looking to upgrade to another disc seeder hopefully with the ability of seed singulation for precise seed placement, parallelogram for depth control and improved press wheels with a seed firmer to improve soil-seed contact."

Tom believes that the seeding systems trial at Hart has been a way for farmers to discuss where they can improve. "You want farmers to question their system and that's what Dad and I are always doing, it's to see where we can improve and why we're doing the things that we are."

Farmer story 3

New disc seeder adopter

Farmer	Patrick Neal
Location	Ngapala
Property size	1360 ha arable + grazing country
Rainfall	450 mm annual 325 mm growing season
Soil type	Red loam – brown clay loam
Enterprise	65% seeding plus sheep Cereals, legumes and canola with 1500 ewes
Seeder	John Deere 1890 bar, single disc at 7.5 inch row spacing with Aricks Wheels (residue manager)

Patrick Neal has been no-till farming for 15 years on his Ngapala property and has recently shifted to a disc system for better stubble handling. He purchased his nine metre wide John Deere 1890 bar, single disc system three years ago to replace their previous Conserva Pak knife-point system.

For Patrick the shift to a disc system was to eliminate issues they had with rocks at seeding. “We have plenty of rocks on our property and our old Conserva Pak tyned machine used to pull them up out of the ground which created issues later on.” Patrick also wanted to change the row spacing of their system from 12 inch with their knife-point system to 7.5 inch spacing. “We wanted to get our row spacing narrower for better weed competition and to grow a bit more of a canopy. To achieve this narrower row spacing we needed the disc to handle our stubble load.” Although not the primary driver for his purchase, other disc seeder aspects such stubble handling and improved soil cover were added incentives for Patrick.

Issues with rocks at seeding was the main reason for Patrick Neal’s shift to a disc system.

Patrick's cropping program consists of canola followed by two wheat crops in a row then a pulse crop, mainly beans or lentils, followed by another wheat or barley crop. Vetch pastures fit into the rotation in paddocks where harvesting pulses can be an issue. Livestock are only grazed on Patrick's cropping area during summer.

Rye grass and wild oats are the main problem weeds on Patrick's property. Brome grass is also present but Patrick says at this stage it's not too big of an issue for them. "We do not grow oaten hay so our strategy consists mainly of chemical control (including pre and post emergent applications and crop topping), windrow burning and now narrow row spacing." In terms of herbicides, Patrick is getting good results from Sakura® and Boxer Gold® within their cereal crops and is still able to use trifluralin in their break crops.

Hair pinning has also been an issue which Patrick attributes to grazing sheep on their stubbles. "We try not to overgraze our stubbles. We can get through the stubble with no problems when they are standing up but by the time we have grazed them and particularly with narrow row spacing the sheep tend to knock them." Arick's wheels were added to the seeder at the time of purchase to alleviate this issue and Patrick has been happy with the results. "We set them up pretty aggressively this year to try and move more stubble and we have also added extra weight to the machine to penetrate the stubble better."

"We wanted to get our row spacing narrower for better weed competition and to grow a bit more of a canopy. To achieve this narrower row spacing we needed the disc to handle our stubble load." **Patrick Neal**

Patrick says that his maintenance has increased since his shift to disc system but the maintenance has been more preventative rather than during seeding. "In comparison to our previous tyned machine we don't break as many parts on our disc seeder, so we're not fixing our seeding system as often during the season. We do wear discs a bit more on our country so we do have to change them halfway through the season which takes almost a full day but we are prepared for when that needs to happen."

In terms of upgrading, a new purchase isn't likely but Patrick said he would be hesitant to go back to a knife-point system due the issues he has with rocks at seeding. "At this stage the only thing I would consider moving to would be a machine that requires a little less maintenance and penetrates stubble better if one happened to come along. For now though we're happy with what we've got."

The ability to see the trial and to compare between the different systems has been an interesting aspect of the seeding systems trial at Hart for Patrick. "Being able to easily see the job that each machine does and then being able to compare how similar it is to your own system is one thing I've gotten out of it."

Farmer story 4

The full circle on seeding systems

Farmer	Andrew Sargent
Location	Crystal Brook
Property size	2000 ha
Rainfall	400 mm annual 300 mm growing season
Soil type	Sandy loam
Enterprise	100% seeding cereals, legumes, canola and oaten hay
Seeder	Flexicoil ST820 bar, knife-point paired row boots with 300 mm row spacing and press wheels.

Andrew and his father Malcolm farm 2000 hectares at Crystal Brook and have been no-till farming for 17 years. During this time they have used both knife-point and disc seeding systems. Their main aim over the years has been to retain a high amount of stubble without reducing germination.

The Sargent's purchased their current Flexicoil ST820 bar four years ago. Their seeding system consists of an 18 metre wide bar, 300 mm row spacing, paired row boots and a sowing speed of 7.5 km/h. Prior to this they had a single disc system for two years. Andrew says they observed issues with reduced establishment, hair pinning and herbicide incorporation. "I think we got lucky with the years that we had our disc seeder as they were favourable years so it didn't matter that we had a lower plant count."

Andrew Sargent, pictured above, farms with his father Malcolm at Crystal Brook and has used both knife-point and disc seeding systems.

After they sold their disc seeder the Sargent's trialed four different seeder bars with knife-points to figure out what could get through their stubble the best. "We still wanted to retain a similar amount of stubble as we could with the disc. For us, we found this could be achieved with a knife-point system and it was easier in terms of herbicide selection for better weed control."

A crop rotation of two cereals in a row (wheat or barley) followed by a break crop of either canola or a pulse crop (including lentils, peas, beans and chickpeas) is used on the Sargent's farm.

Rye and brome grass are the two main in crop weed issues for the Sargent's. Although they only had their disc seeder for two years, they did notice brome grass numbers increase rapidly in this time. "We had huge problems with brome grass. Our brome grass numbers blew out massively when we had our disc system because we weren't getting the herbicide incorporation and we are still getting on top of this problem four years later," Andrew said. A combination of pre and post emergent herbicides, crop topping and incorporating legume crops for the use of selective herbicides are all aspects of the Sargent's integrated weed control strategy.

Andrew says that more recently they have looked into including oaten hay in their rotation and harvest weed seed control. "We did trial a weed seed destructor for one year, but it was a bit hard to see results after just one season. We completed some narrow windrow burning last year in our problem patches and it seems to have work really well, it just takes a lot of preparation."

"What we got out of the process of trying a couple of different bars was that it didn't really matter what you had, it was more about timing. We just wanted a machine that would go through our stubble and was going to be reliable." **Andrew Sargent**

Other problems that the Sargent's have faced with their current seeding system include limited trash handling and seed placement which Andrew attributes partly due to not being able to inter-row sow. "We haven't modified that much on our machine but we are looking at implement steer. If we can get the inter-row sowing right then the other stuff will come by itself."

As it was only four years ago that the Sargent's purchased their current seeding system Andrew says that a new purchase isn't likely. "Implement steer is the only thing we'll look at changing in the near future. Ideally we'd look at a parallelogram type seeder but I think at this stage trash flow is an issue for those machines. If we can get the inter-row sowing going right then we might look at taking the punt on a parallelogram type seeder."

Similar to other farmers Andrew says that the interesting thing that they have gotten out of the cropping systems trial is that there was no real difference between machine types. "I guess it depends what else you have got your seeding system for because at Hart there aren't any real limitations. What we got out of the process of trying a couple of different bars was that it didn't really matter what you had, it was more about timing. We just wanted a machine that would go through our stubble and was going to be reliable."

Farmer story 5

Simplicity seeding

Farmer	Michael Jaeschke
Location	Hart
Property size	670 ha
Rainfall	425 mm annual 320 mm growing season
Soil type	Red brown loam, sandy rises (sand over clay)
Enterprise	85% seeding plus sheep Cereals, legumes with 600 self-replacing Dohne Merino
Seeder	Flexicoil 820, 100 mm wide points, 8 inch row spacing with finger harrows

For Hart farmer Michael Jaeschke, his seeding system is all about flexibility. Michael has had his Flexicoil 820 bar since 1999. “The Flexicoil was expensive at the time but I knew it was going to last me a long time. I’m going into my 17th season and it’s still good. It’s a solid machine and I have had no problems at all, it’s a simplicity seeder.”

Having the option of ripping up or direct drilling has been the main reasoning for Michael’s choice of seeding system. “I have a pretty strong breakout so I can still direct drill the same as anyone else, my only problem is that if soil moisture is marginal, the soil comes up a bit cloddy. My soil is pretty friable so I don’t dry sow but because I have a smaller property I can be done seeding in two weeks.” His system consists of knock on points ranging from 2 inches to 4 inches and 7.2 inch row spacing. The past five to six years Michael has slowed his sowing speed down to 8.5 km/h to reduce soil throw.

Michael Jaeschke farms at Hart and says his seeding system is all about simplicity.

As Michael has livestock within his system his crop rotation consists of durum, bread wheat, barley for livestock feed and then a legume crop. “Durum is usually after peas and my pastures tend to just slip in wherever I think there is a weed issue.”

Ryegrass is the main problem weed and Michael’s control strategy consisting of a knockdown and a full cut at seeding. Livestock are also used for weed control especially within his barley pastures. “The sheep tend to chase the ryegrass before they start eating the barley, my theory with ryegrass is because I’ve got sheep if you’re going to disturb the soil, disturb it properly.” Trifluralin will go on after seeding and Logran® gets mixed in a lot more evenly with it being sprayed and then prickle chained.

“This year we introduced Boxer Gold® into the trifluralin/ Logran® mix, post seeding/pre-emergent. There have been good results so far on ryegrass numbers, but we had problems with crop emergence on our limestone ground due to heavy rainfall after seeding.” Michael also uses a selective herbicide within his pea crops. “We keep a close eye on our cost of production. If there is an issue that we don’t think needs to be sprayed then we won’t.”

“The Flexicoil was expensive at the time but I knew it was going to last me a long time. I’m going into my 17th season and it’s still good. It’s a solid machine and I have had no problems at all, it’s a simplicity seeder.” **Michael Jaeschke**

The main modification that Michael has made to his seeding system is the ability to switch from a 7 inch sweep point to 2 inch or 4 inch knock on points with the use of clips. Michael says that this increases his flexibility by having knock on points for deep ripping if needed. Apart from this, there have not been many changes to the seeder but Michael says the amount of direct drilling he does has increased a bit. “Depends on what I’m trying to achieve but either 2 inch or 4 inch points.”

“A couple of years ago I had a few paddocks with ryegrass so I did an early till and then put wide sweeps on and came back and sowed it. Last year I just put 4 inch points on and direct drilled and prickle chained afterwards so I’m still getting good control. That’s my flexibility.”

Michael also switched his pastures from medic to barley and increased the amount of peas in his seeding program. “I’ve actually got more sheep and I’m growing better crops than what I had with medic pastures. I’m growing a lot more peas and with a year like the last our wheat was going APW - H1 and we didn’t have any screenings problems.”

For Michael a new seeder purchase isn’t likely in the short term. Michael has sown the strategic treatment in the Hart seeding systems trial for the past 16 years. The trial has resulted in more of a nutrition than seeder message for Michael. “It’s not so much the seeding system selected that makes the difference, it’s the fertiliser.”

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Appendix 1.

Grain screenings (%) for seeding system and nutrient treatments from 2000-2015.

		Strategic		No-till		Disc		LSD (P≤0.05)		
Year	Crop	Medium	High	Medium	High	Medium	High	seeder	nutrition	seeder × nutrition
2000	Barley	12.1	14.2	11.1	13.8	15.7	16.9			
2001	Canola									
2002	Wheat	1.6	1.4	1.6	1.4	1.8	1.7	ns	ns	ns
2003	Wheat	2.3	1.7	2.4	2.1	2.1	2.5	ns	ns	ns
2004	Barley	1.9	8.9	2.0	8.9	2.2	7.7			2.8
2005	Peas									
2006	Durum	1.8		3.7		2.5		ns		
2007	Wheat	0.5	0.6	1.9	2.3	3.4	5.7	ns	ns	ns
2008	Wheat	8.0		6.3		7.3		2.8		
2009	Barley	5.4		4.8		5.1		ns	ns	ns
2010	Canola									
2011	Wheat	1.1	1.7	1.0	1.5	1.8	2.0	0.5	0.41	ns
2012	Peas									
2013	Wheat	-	-	5.1	7.4	4.7	6.6	ns	ns	ns
2014	Barley	11.1	26.8	5.9	28.2	6.5	24.1	ns	ns	ns
2015	Canola									

Grain test weight (kg/hL) for seeding system and nutrient treatments from 2004-2015.

		Strategic		No-till		Disc		LSD (P≤0.05)		
Year	Crop	Medium	High	Medium	High	Medium	High	seeder	nutrition	seeder × nutrition
2004	Barley	58.2	52.4	56.7	52.0	56.5	52.2			2.5
2005	Peas									
2006	Durum	No data		No data		No data				
2007	Wheat	No data		No data		No data				
2008	Wheat	No data		No data		No data				
2009	Barley	64.5		64.9		65.2		ns	ns	ns
2010	Canola									
2011	Wheat	78.4	76.0	79.0	77.0	77.3	76.0	1.1	0.92	ns
2012	Peas									
2013	Wheat	-	-	73.1	70.3	73.4	73.6	ns	1.77	ns
2014	Barley	67.9	65.6	70.1	66.4	69.5	65.8	ns	1.4	ns
2015	Canola									

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