MURRUMBIDGEE Landcare INCORPORATED

Cereal Stubble Management On-farm Demonstrations and Case Studies 2009

Murrumbidgee Landcare Inc.

Harden Murrumburrah Landcare Group, Junee Area Landcare Network, Junee Reefs TopCrop Group, Eastern Riverina Landcare Network and Mirrool Creek Landcare Group, part of Central Riverina Landcare Network

Woolworths the fresh food people

NSW GOVERNMENT Industry & Investment

LANDCARE AUSTRALIA

Murrumbidgee CATCHMENT MANAGEMENT AUTHORITY

EH GRAHAM CENTRE for Agricultural Innovation
An alliance between Charles Sturt University and Industry & Investment NSW

Acknowledgements

Author: Di Holding, AnDi Communications.

Project management: Phil Bowden, District Agronomist, Industry & Investment NSW, Cootamundra and Dr John Oliver, Research Leader, Farming Systems South, Industry & Investment NSW.

Project technical managment and extension: Tony Pratt, Technical Officer, Industry and Investment NSW.

Technical assistance: Michael Cronin.

Report production: AnDi Communications (layout, design, image production, editing, proof reading), Tony Pratt, I&I NSW (editing) and Phil Bowden, I&I NSW (editing)

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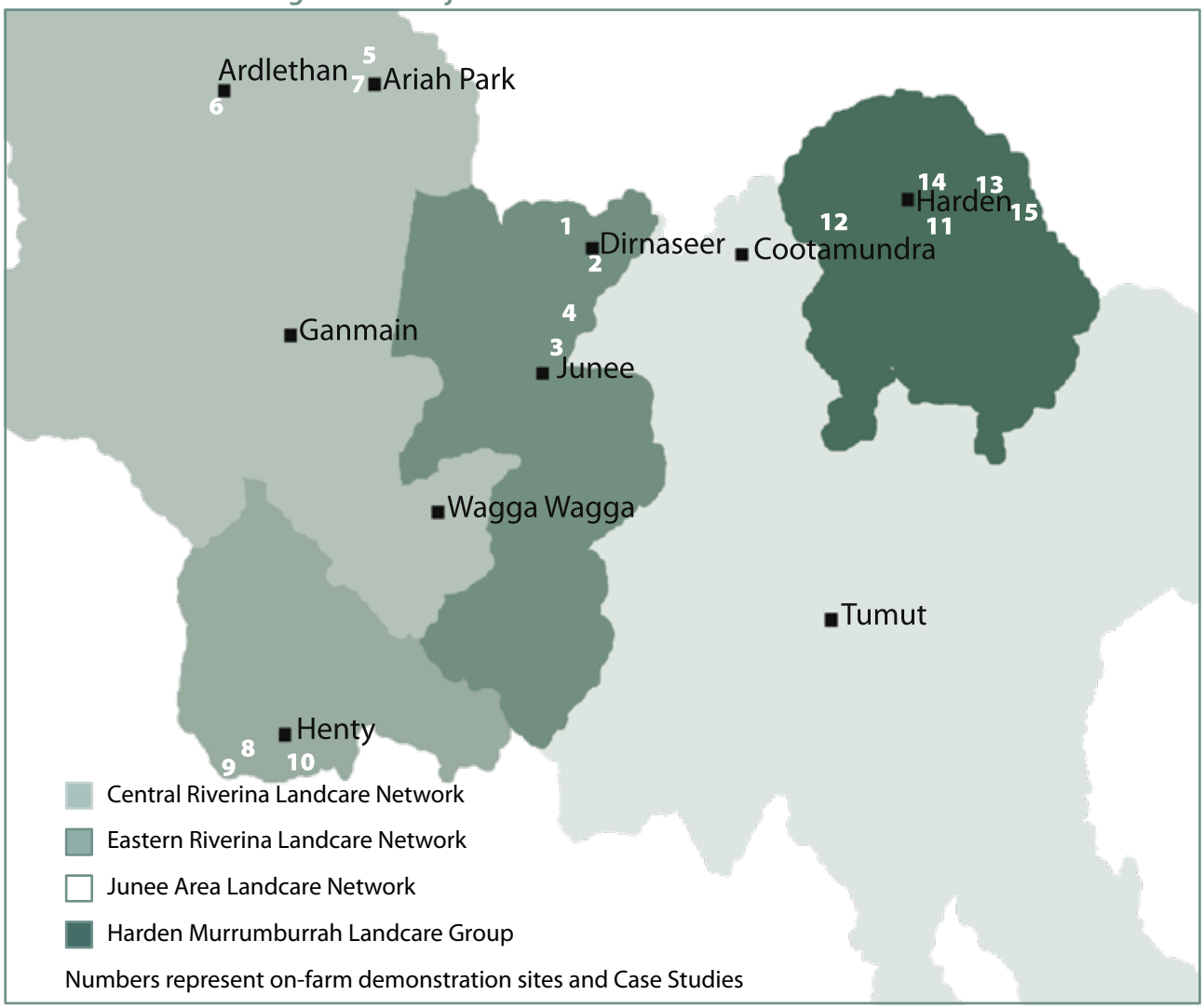
Original concept: Harden Murrumburrah Landcare Group initiated this work on methods to manage cereal stubble in 2005. They have continue in their search for answers in this project and the Case Studies from their 2008 report are included here as Case Studies 11 to 15.

Murrumbidgee Landcare Inc.

Cereal Stubble Management Project Landcare areas and on-farm demonstration sites.



Project background

The Cereal Stubble Management Project is being managed by Murrumbidgee Landcare Inc. in partnership with Industry & Investment NSW (formerly NSW Department of Primary Industries). Funding is provided by the Woolworths Sustainable Farms Drought Program and Murrumbidgee Catchment Management Authority. The project builds on work already conducted by Harden Murrumburrah Landcare Group. The project is comparing a range of stubble management practices for their benefits in conserving soil moisture; providing a protective soil cover; and improving crop productivity.

Aims

The project aims to:

- Compare different farming systems using different seeding and tillage methods.
- Evaluate the effects of stubble grazing on soil and crop parameters.
- Investigate the effects of stubble retention and management on soil parameters.

On-farm demonstrations

Demonstration sites were set up in 2008 on 15 case study farms across four Landcare districts in the South West Slopes cropping region of NSW (see map opposite).

Taking soil cores to a depth of 60 cm to measure soil moisture and soil nutrient levels after harvest.

Farming systems in the case study farms included no- and minimum-till cropping, both with and without livestock. Seeding systems included tine and disc seeders, airseeders and modified combines.

Treatments

The demonstrations looked at a range of stubble treatments and compared typical farm practice with alternate treatments chosen by members of each Landcare group. Stubble management treatments included:

- Nil (normal harvest height, no grazing, summer weeds controlled)
- Low cut at harvest
- Mulching (various methods)
- Incorporation, with stubble breakdown products
- Inter-row sowing
- Burning
- Baling
- Grazing.

Measurements

The measurements taken to compare stubble management treatments are listed below. Measurements were made at harvest and/or just prior to sowing. Those measured at both times were to identify changes over summer.

- Stubble height (cm) and ground cover (%)
- Stubble load (crop residue dry matter, t/ha)
- Soil moisture (60 cm deep core, mm)
- Soil bulk density
- Soil nutrient levels at different depths (ppm)
- Plant population after crop establishment (plants/m^2).

Stubble load, ground cover and plant population were measured both directly behind the harvester and 3 m to one side of the centre of the header track. This was to identify any differences which may result from the inability of harvesters to effectively spread crop residue evenly across the entire width of the header.

Note: The measurement of plant population at different points across the width of a seeding machine assumes that the seeding rate is identical in each row of the seeding machine.

Note: Stubble load was measured by collecting the stubble of a set area from a randomly chosen location and weighing it. There is enormous natural variation in stubble levels across any paddock. This natural variation needs to be kept in mind when interpreting results. The measurements should be used to indicate a low, medium or high level of stubble, rather than an exact quantity.

Field days

A number of field days and smaller paddock walks were held at each site so that group members could observe the sites at different stages through the season. These events encouraged participants to share information on machinery setup and experiences associated with managing stubble—both good and bad.

Field days encourage participants to inspect demonstration plots and machinery, and swap ideas.

Weed and tillage definitions

Table 1 Weeds referred to in this report.

Common name	Botanical name
Annual ryegrass	*Lolium rigidum*
Barley grass	*Hordeum leporinum*
Brome grass	*Bromus* sp.
Cape weed	*Arctotheca calendula*
Paterson's curse	*Echium plantagineum*
Silver grass	*Vulpia bromoides*
Toad rush	*Juncus bufonius*
Wild oats	*Avena fatua, A. ludoviciana*
Wild radish	*Raphanus raphanistrum*
Wireweed	*Polygonum aviculare*

Table 2 Tillage definitions used in this document.

Term	Definition
Reduced-till	one cultivation prior to full-cut sowing
Direct-drill	one pass sowing with a full-cut
No-till	knife or disc sowing, 5–20% soil disturbance

Description of treatments

Harvest height

Normal harvest height is the height used by the co-operating farmer when harvesting cereals. *Low harvest height* aims to reduce the length of straw pieces to improve flow through the seeder. Low harvest height was generally half the height above the ground of the normal height (e.g. normal height 41 cm, low harvest height 23 cm).

Graze

Grazing is commonly used for stubble management to:

- reduce the quantity of stubble by grazing;
- break stubble into smaller lengths; and
- control weeds.

Both heavy and light grazing treatments were used. The level of grazing for each treatment (DSE and grazing period) was determined by the individual farmer. Light grazing treatments may vary from site to site.

Burn

One of the key aims of this project is to reduce the need to burn crop stubbles. However a late burn, in mid to late autumn, may be a compromise between full stubble retention and a hot early-autumn burn, which leaves the soil bare for many weeks prior to sowing the crop. A late burn treatment was used at a number of the demonstration sites.

Apply biological product

A biological product contains beneficial bacteria and is applied to stubble soon after harvest with the aim of increasing the number of beneficial bacteria in the soil and stubble and therefore increasing the rate of residue breakdown. Rainfall is required to stimulate biological activity. Rainfall is quite unreliable during the southern NSW summer and autumn. Conditions when products were applied to treatments in 2009 were less than favourable.

Results achieved in past demonstrations at Harden have been quite variable.

Mulch

Mulching, in general, is used to break lengths of straw into smaller pieces, increasing the rate of breakdown and reducing the problems of trash flow at seeding. There is a wide range of methods used to mulch crop residue. A number of these were tested in the stubble demonstrations.

Harrows knock stubble over and break some of the straw into pieces. If done soon after harvest it can increase the rate of stubble breakdown, providing there is rainfall to aid the process.

A **prickle chain** is commonly used behind a seeder to aid seed covering and surface soil levelling. It can be used in the same way as a set of harrows but is slightly more aggressive.

A **disc chain** is a series of discs linked together and is used to smash stubble. It is quite aggressive and will cut out summer growing weeds (see photo page 43).

A **flail mulcher** is an aggressive mulcher with flails (or swinging pieces of steel attached to a central rotating shaft, PTO driven) used to smash straw into small pieces.

Coolamon Harrows are a heavy rod mesh used to flatten stubble.

The **Stubble Cruncher** is an implement designed to knock down and cut stubble to reduce the length of the straw and increase the rate of breakdown. The rolling, cutting action was based on the action of a bulldozer's track.

The Stubble Cruncher knocks down cereal stubble and splits it open every six inches. This means the soil retains moisture and the stubble breaks down faster than when it is left standing. The Stubble Cruncher was developed in southern NSW by Ariah Park farmer Colin Harper.

The Stubble Cruncher.

The **Trash Cutter** lays stubble down across the front of self-sharpening coulters which cut and evenly spread the trash. The stubble is cut into short pieces and left on the soil surface.

The Trash Cutter results in little or no soil disturbance and aims to optimise soil moisture holding capacity, increase the rate of stubble breakdown and reduce trash flow problems at seeding.

The K-Line Trash Cutter.

Offset disc

The offset disc is an aggressive cultivation used to chop and bury the stubble. It leaves the ground surface quite rough and generally requires a pass with a set of harrows or a shallow tine cultivation.

Inter-row sow

Inter-row sowing uses high accuracy (plus or minus 2 cm) GPS auto steer to sow the crop between the previous year's crop rows, in the inter-row area. This results in the new crop germinating and establishing between rows of standing stubble.

High accuracy or corrected GPS signal (RTK) and autosteer facilitates sowing this season's crop in the inter-row zone of last year's stubble.

Demonstration sites

The 15 on-farm demonstration sites covered a range of soil types and environments. Soil cores were taken to a depth of 60 cm and separated into four 15 cm increments (0–15 cm, 15–30 cm, 30–45 cm and 45–60 cm). Standard soil tests were completed and the results for the top layer (0–15 cm) are presented in Table 3. The results for the subsoil layers are presented in Table 14 (page 13).

All sites are acidic (pH_{CaCl_2} less than 5) with moderate phosphorus levels. Cation exchange capacity for all sites except Site 1 were quite low (less than 8 meq/100 g), indicating relatively light soils.

Junee Reefs

Junee Reefs is in the heart of the southern NSW mixed farming zone. The area has relatively reliable rainfall and livestock plays a very important role in the majority of farm businesses. There is a strong desire to retain the crop stubble and avoid burning, to improve soil moisture holding capacity and soil carbon levels. This has lead to the challenge of how to manage the crop residues so seeding can take place without trash flow issues. One of the key questions is "Can stubble be grazed then sown through, and if so how?"

Four sites (see map inside front cover) were set up by the Junee Reefs TopCrop Group to investigate a number of ideas aimed at solving the stubble problem.

Stubble treatments

A diverse range of stubble treatments (see Table 5) were implemented in the Junee demonstrations. These included grazing,

Table 3 Soil characteristics post-harvest 2008 for each on-farm demonstration site, 0-15 cm.

Note: this information is from demonstration plots, not from a replicated trial.

Site	Colour	Texture	pH	C	N	P	S	CEC
Junee Reefs								
1	red	sandy loam	5.0	1.10	13.0	27	15.0	12.20
2	red	sandy loam	4.7	1.10	7.0	26	8.6	6.60
3	red-brown	sandy clay	5.0	1.00	9.6	31	9.8	6.57
4	red-brown	sandy loam	4.5	0.91	13.0	21	8.7	5.13
Mirrool Creek								
5	red-brown	sandy clay loam	4.4	1.10	24.0	16	5.8	5.29
6	red-brown	sandy clay loam	4.8	0.88	4.6	46	15.0	6.41
7	red-brown	sandy clay loam	4.7	0.77	<1	30	7.0	5.84
Henty								
8	red-brown	sandy clay loam	4.8	1.20	2.7	35	8.4	7.52
9	brown	sandy clay loam	4.4	0.98	4.9	33	6.5	4.36
10	red-brown	sandy clay loam	4.2	0.67	3.8	37	8.6	2.95
Harden								
11	grey-brown	sandy clay	5.1	0.93	8.1	40	4.4	5.39
12	red-brown	sandy clay loam	4.7	1.10	6.6	26	16.0	5.18
13	brown	sandy clay	4.4	0.90	5.4	23	5.0	2.70
14	brown	sandy clay loam	4.9	0.89	12.0	36	7.5	3.04
15	yellow-brown	sandy clay	4.8	1.10	6.4	25	9.6	4.81

pH 1:5 $CaCl_2$ N nitrate (mg/kg) S sulphur (mg/kg)

C Organic C (%) P phosphorus (mg/kg) CEC cation exchange capacity (meq/100 g)

On-farm demonstration at Site 1 showing normal harvest height heavily grazed (left) and nil treatment (ungrazed, right).

reducing cutting height at harvest, stubble management implements and/or burning to reduce stubble load.

Demonstration paddocks were sown to wheat (Site 3), canola (Sites 1 and 4) or wheat undersown with legume pasture (Site 2). Management operations including sowing and herbicide application was the same as the rest of the paddock and done by the co-operating farmer.

Explanation of results

Note: these results are from demonstration plots, not from a replicated trial. Results indicate trends only and have not been scientifically analysed.

Stubble load

Stubble load was much higher at Sites 3 and 4 than at Sites 1 and 2 (Table 5). Stubble load directly behind the header was about twice that measured three metres away from the centre of the header tracks.

Bare ground and canola stalks post windrowing in late burn treatment at Site 4.

Standing cereal stubble from 2008 between canola stalks post windrowing in low harvest height treatment at Site 4.

Soil water

Change in soil water from harvest to sowing the following year is presented in Table 5 for each treatment. Although rainfall from November 2008 to May 2009 was greater than 200 mm at each site, soil water accumulation (to 60 cm deep) over summer was minimal. The best soil water accumulation occurred where stubble was not grazed or burnt. In general, even light grazing reduced soil water accumulation compared to ungrazed treatments

Table 4 Characteristics for each of the four demonstration sites at Junee.

Note: this information is from demonstration plots, not from a replicated trial.

Site	Crop, variety	Sowing cultivator, covering device [S]	Row space (mm)	Sowing date	Rainfall [R] (mm)	Soil nitrate [N] (mg/kg)
1	Canola, Tawriffic TT[Φ]	Flexicoil airseeder, Knuckeys press wheels and sowing boots	300	3 May	209	39.5
2	Wheat, EGA_Gregory[Φ] (undersown)	John Deere combine, finger harrows	185	15 May	215	11.6
3	Wheat, Whistler	John Deere disc seeder, press wheels	250	6 May	267	22.4
4	Canola, Tawriffic TT[Φ]	Conserva Pak airseeder, press wheels	300	6 May	238	27.3

[R] rainfall from harvest to sowing, November 2008 to May 2009
[S] for more information on the seeding system see the individual case study on pages 14 to 21
[N] soil nitrate at harvest 2008

Table 5 Stubble management treatments, stubble load at sowing, change in soil water and plant population of 2009 crop at each of the four demonstration sites at Junee.

Note: this information is from demonstration plots, not from a replicated trial.

Site	Stubble treatment	Stubble at sowing 2009 (t/ha)		Change in soil water [W] (mm)	Plant population 2009 (plants/m^2)	
		Behind [B]	3 m out [C]		Behind [B]	3 m out [C]
1	Nil	5.5	3.5	+37	43	53
	Lightly grazed (20 DSE for 10 days)	4.5	2.5	+9	48	51
	Heavily grazed (80 DSE for 21 days)	na	2.7	+3	45	44
	Low harvest height, no grazing	9.8	3.3	+28	37	52
	Low harvest height, lightly grazed	3.8	2.9	+4	45	48
	Low harvest height, heavily grazed	na	2.7	+19	43	57
2	Grazed	7.2	4.2	+6	na	na
	Grazed, diamond harrowed	5.0	3.6	+2	na	na
	Grazed, late burn	3.6	3.9	+7	na	na
	Biological product, offset disc	2.8	2.8	+1	na	na
3	Nil	14.5	7.7	+17	91	106
	Trash cutter	12.0	5.1	+14	90	98
	Trash cutter, grazed	12.7	5.4	+10	113	113
	Grazed	11.4	6.3	+2	94	107
	Grazed, late burn	9.6	6.0	+8	109	100
4	Flail mulcher	10.3	4.3	+16	61	66
	Stubble Cruncher	11.5	6.1	na	57	60
	Late burn	10.1	5.1	+8	58	56
	Inter-row sow	7.6	4.9	+17	52	56
	Low harvest height	14.2	3.3	+10	47	51

[B] in the header trial, immediately behind the header
[C] 3 m to the side of the centre of the header trail
[W] change in available soil water from 0 to 60 cm depth between harvest 2008 and sowing 2009

at the same site. Stubble load did not appear to have an impact on the amount of water stored in the soil over summer.

Crop establishment

All crops established well and within the target range identified by each farmer co-operator. The results were quite variable and showed no real trend caused by the method of stubble management nor the position across the paddock relative to the header track.

Weeds

Weeds were hard to find at all of the Junee Reefs sites. There was no treatment or seeder type (disc versus tine) where weeds could be found.

All crops were vigorous and competitive. At Site 1 there was a difference in crop canopy between the grazed and ungrazed treatments. Where stubble was retained and ungrazed the canola plants were 30 cm taller, less water stressed and larger, compared to grazed plots.

Site 1 canola crop mid flower. Poor and uneven establishment on the heavily grazed treatment resulted in a thin crop with delayed flowering, a disaster in the tough spring conditions which prevailed.

Mirrool Creek

The Mirrool Creek Landcare Group is active around Ariah Park and Ardlethan in southern NSW. The district is the lowest rainfall zone in this Stubble Management Project, although rainfall over the summer period in 2008-2009 at Sites 5 and 7 was equal to or higher than the other sites.

The area is dominated by annual winter cropping and livestock remain an important component of many farm businesses. Site 5 and 7 include livestock in their enterprise mix while Site 6 is continuous crop, including 10% fallow.

Grain growers in the district have been looking at ways of retaining cereal stubble and maximising storage of any rain that falls over summer for use in the subsequent winter crop. This is particularly important in seasons, like those in recent years, with very low in-crop rainfall. In these seasons it is difficult to grow enough dry matter to achieve adequate stubble cover.

Stubble treatments

The Mirrool Creek farmers key aim is to retain groundcover to optimise soil water storage whilst being able to sow through the trash without blockages. Their chosen treatments reflect this and include:

- Nil, stubble left standing
- Light and moderate grazing
- Lower than normal harvest height
- Various mechanical treatments such as harrows, Stubble Cruncher, prickle chain and mulching.

Explanation of results

Note: these results are from demonstration plots, not from a replicated trial. Results indicate trends only and have not been scientifically analysed.

Stubble load

Stubble loads were quite light at Sites 5 and 7 reflecting the low in-crop rainfall during the 2008 crop season. This resulted in reduced crop dry matter (and stubble load) compared to other years and demonstration sites.

There was no effect of stubble management treatment on stubble load at sowing in 2009 in the three demonstrations. Similar to the other demonstration sites, the stubble load behind the header was slightly higher than the load 3 m to the side of the header track.

Soil water

Rainfall from harvest to sowing (November 2008 to May 2009) was over 230 mm for Sites 5 and 7 and only 164 mm for Site 6 (see Table 6). This high summer rainfall did not translate into stored soil water at Site 5 due to growth and delayed control of summer weeds. At Site 6 the rainfall that did occur was in small events. This

The 2008 stubble load was quite low at Site 7 due to the extremely low rainfall during spring 2008. Temporary fencing was used to exclude sheep from the low harvest height (ungrazed) treatment.

Table 6 Characteristics for each of the three Mirrool Creek demonstration sites.

Note: this information is from demonstration plots, not from a replicated trial.

Site	Crop, variety	Sowing cultivator, covering device [S]	Row space (mm)	Sowing date	Rainfall [R] (mm)	Soil nitrate [N] (mg/kg)
5	Wheat, Ventura(ф)	Horwood Bagshaw Stubble Master chisel plough, press wheels	300	25 May	239	39.7
6	Long fallow	na	260	na	164	7.6
7	Wheat, Sunzell(ф)	John Deere chisel plough, press wheels	300	13 May	277	4.0

[R] rainfall from harvest to sowing, November 2008 to May 2009
[S] for more information on the seeding system see the individual case study on pages 22 to 27
[N] soil nitrate at harvest 2008

combined with low stubble cover due to the drought in 2008 resulted in a net soil water loss between harvest and sowing in 2009.

Crop establishment

The established plant population at Sites 5 and 7 was within the target range for wheat and was quite uniform at both sites, not varying between treatment nor between directly behind the header or to the side of the header track.

Weeds

Weed population was assessed at Site 5 and 7 (see Table 7). A moderate population of weeds was found across both sites. There was more wild oats (8 plants/m^2) in the baled (ungrazed) treatment than the grazed treatment (5 plants/m^2) at Site 5. The dominant weeds at Site 7 were wild oats and a range of broadleaf weeds.

Table 7 Weed populations at selected treatments at Site 5 and Site 7.

Site	Treatment	Weed population (plants/m^2)
5	Grazed	7.8
5	Baled	6.9
7	Low harvest height	7.9
7	Low harvest height, grazed	5.9

Henty

The three Henty demonstrations are spread over quite an area representing the Eastern Riverina Landcare Network. Each cooperator manages an extensive annual winter cropping program, with a heavy reliance on livestock, either Merinos crossed to terminal sires or cattle.

As a general rule, autumn stubble burning has been a key operation for the majority of grain growers in the district, but there is a keen desire to move away from the practice.

The demonstrations represent a range of seeding machinery and include:

- A modified combine with Flexicoil tynes and knife points (see photo page 9)
- A parallelogram-design tine airseeder (see photo page 32); and
- A single disc seeder (see photo page 10).

Each seeder is fitted with press wheels.

Stubble treatments

The treatments chosen aimed to reduce the quantity of residue from the previous crop remaining at sowing, reducing issues of trash flow. Treatments included grazing, harrowing, burning and the use of a biological residue breakdown product.

Table 8 Stubble management treatments, stubble load at sowing, change in soil water and plant population of 2009 crop at each of the three Mirrool Creek demonstration sites.

Note: this information is from demonstration plots, not from a replicated trial.

Site	Stubble treatment	Stubble at sowing 2009 (t/ha)		Change in soil water [W] (mm)	Plant population 2009 (plants/m^2)	
		Behind [B]	3 m out [C]		Behind [B]	3 m out [C]
5	Grazed	6.6	4.9	-18	94	98
	Baled plus grazed	4.9	3.0	-37	91	97
	Rolling harrows plus fertiliser	7.4	3.7	-20	96	86
6	Nil	11.0	7.3	-11	na	na
	Stubble Cruncher	10.8	5.2	-18	na	na
	Prickle chain	12.0	6.8	-14	na	na
	Biological product	9.8	10.5	-18	na	na
7	Grazed	2.6	4.7	0	83	84
	Low harvest height	2.6	3.6	+10	83	74
	Low harvest height, grazed	2.5	5.7	+5	72	72

[B] in the header trial, immediately behind the header
[C] 3 m to the side of the centre of the header trail
[W] change in available soil water from 0 to 60 cm depth between harvest 2008 and sowing 2009

Nil stubble treatment (normal harvest height, no grazing) at Site 10 . Inter-row sowing leaves the previous season's standing stubble in tact.

The Newton's Agrowdrill combine has been modified—Flexicoil tines and knife points have improved trash flow and accuracy of seed placement. This seeder was used to sow Site 9.

Explanation of results

Note: these results are from demonstration plots, not from a replicated trial. Results indicate trends only and have not been scientifically analysed.

Stubble load

Stubble was quite uniform across the three Henty sites at 8-10 t/ha. There was little difference in stubble load (at sowing in 2009) between treatment or zone (behind the header or 3 m to the side) at any of the sites.

Soil water

Soil water stored to 60 cm depth was related to summer rainfall, with Site 9 having less than half the rainfall from November to May and the least amount of water stored. There was little variation at Site 9. At Site 8 the light grazing resulted in a net water loss, while the ungrazed treatments had a substantial net water gain. At Site 10 the results were reversed. There was no change in soil water in the ungrazed treatment, and a net gain in both the grazed treatments.

High stubble loads (approximately 10 t/ha) at Site 8. Biological breakdown product treatments ungrazed (left) and grazed (right).

Table 9 Characteristics for each of the four demonstration sites at Henty.

Note: this information is from demonstration plots, not from a replicated trial.

Site	Crop, variety	Sowing cultivator, covering device [S]	Row space (mm)	Sowing date	Rainfall [R] (mm)	Soil nitrate [N] (mg/kg)
8	Wheat, EGA Gregory(ф)	John Deere single disc, press wheels	190	13 May	187	5.7
9	Canola, Tawriffic TT(ф)	Agrow plow combine with Flexicoil tynes, press wheels	280	10 May	74	12.9
10	Wheat, Sentinel(ф)	John Deere Conservapak, press wheels	300	9 May	165	30.8

[R] rainfall from harvest to sowing, November 2008 to May 2009
[S] for more information on the seeding system see the individual case study on pages 28 to 33
[N] soil nitrate at harvest 2008

Table 10 Stubble management treatments, stubble load at sowing, change in soil water and plant population of 2009 crop at each of the four demonstration sites at Henty.

Note: this information is from demonstration plots, not from a replicated trial.

Site	Stubble treatment	Stubble at sowing 2009 (t/ha)		Change in soil water [W] (mm)	Plant population 2009 (plants/m^2)	
		Behind [B]	3 m out [C]		Behind [B]	3 m out [C]
8	Nil	7.0	13.9	+40	113	136
	Biological product	9.9	9.6	+20	114	151
	Biological product, lightly grazed	6.2	10.5	-16	148	146
9	Grazed	6.7	8.4	+7	56	50
	Grazed, harrowed	6.3	8.5	+9	57	52
	Grazed, burned	10.2	7.5	+11	58	50
10	Nil	12.8	4.4	0	192	205
	Grazed	11.9	13.4	+10	183	179
	Grazed, burned	na	na	+18	208	225

[B] in the header trial, immediately behind the header
[C] 3 m to the side of the centre of the header trail
[W] change in available soil water from 0 to 60 cm depth between harvest 2008 and sowing 2009

Crop establishment

There was a slight reduction in plant population in the zone directly behind the header at Site 8. Established plant number at each site was within the target range.

Weeds

Weed control at each of the Henty demonstration sites was excellent and few weeds could be found. There was no difference observed between sites or treatments.

Site 8 was sown with a John Deere single disc seeder. This photo is taken from behind the seeding unit. The angled wheel at the back of this disc assembly is used to close the seed furrow created by the disc opener and press wheel (smallest wheel).

Harden

The Harden Murrumburrah Landcare Group on the south-west slopes of NSW has been investigating stubble management methods since 2005. Since the commencement of the on-farm demonstrations stubble loads have been lower than targets. However the demonstrations continue in the hope of testing grain grower ideas under higher stubble loads.

The Harden demonstration sites are in the highest rainfall zone (600 mm average annual rainfall) of all the groups involved in this project. Livestock play an important role in most farm businesses in this area, particularly as many farms include non-arable land.

The district had significant rainfall over the 2008/09 summer/autumn fallow period. Each co-operator measured over 200 mm from November 2008 to May 2009.

Stubble treatments

Stubble management methods used (see Table 12) were:

- Nil (stubble left standing, ungrazed and untreated)
- Nil plus summer weed control
- Graze

- Graze plus mulch
- Graze plus harrow
- Graze plus burn
- Mulch with disc chain
- Mulch (disc chain) plus biological breakdown product
- Incorporation
- Baled.

Explanation of results

Note: these results are from demonstration plots, not from a replicated trial. Results indicate trends only and have not been scientifically analysed.

Stubble load

Stubble loads directly behind the header were much high than in the zone 3 m to the side of the header track. Stubble load showed no trend between treatments. There was natural variation across the paddock.

Heavy stubble load on the lightly grazed and harrowed plot with hair-pinning problems (left) and ungrazed plot (right), Site 13 post sowing.

Soil water

Each site had an increase in stored soil water to a depth of 60 cm between harvest and sowing the following year. There was no real difference in the amount of water stored between stubble management methods.

Crop establishment

Plant number established at Sites 11, 12, 14 and 15 was within target populations for the crop type. At each of these sites there was no effect of stubble treatment but a slight reduction in plant number directly behind the header, compared to the zone 3 m to the side of the header track. Site 13, sown to canola, had low plant population established. The site had a heavy stubble load and there was a large amount of hair-pinning of straw in the seeding furrow at sowing.

Straw hair-pinning was an issue at Site 13 which reduced crop establishment. The rows of standing straw have been pinned into the seed furrow.

Weeds

Weed numbers were assessed at Sites 11, 13 and 15 for a selection of treatments (see Table 13). The dominant weed at Site 11 was annual ryegrass. There were similar

Table 11 Characteristics for each of the four demonstration sites at Harden.

Note: this information is from demonstration plots, not from a replicated trial.

Site	Crop, variety	Sowing cultivator, covering device [S]	Row space (mm)	Sowing date	Rainfall [R] (mm)	Soil nitrate [N] (mg/kg)
11	Canola, Tawriffic TT[Φ]	Flexicoil airseeder, press wheels	230	13 May	225	11.1
12	Wheat, Lincoln[Φ]	AusPlow DBS airseeder, finger harrows	270	31 May	254	23.6
13	Canola, Marlin TT[Φ]	Excel stubble warrior disc seeder,	230	26 April	235	8.4
14	Wheat, Lincoln[Φ]	Modified Shearer trash culti drill, press wheels	200	25 May	122*	61.0
15	Wheat, Lincoln[Φ]	Conserva Pak airseeder, wide press wheels	300	26 May	211	10.6

[R] rainfall from harvest to sowing, November 2008 to May 2009; * Jan to May only
[S] for more information on the seeding system see the individual case study on pages 34 to 33
[N] soil nitrate at harvest 2008

Table 12 Stubble management treatments, stubble load at sowing, change in soil water and plant population of 2009 crop at each of the four demonstration sites at Harden.

Note: this information is from demonstration plots, not from a replicated trial.

Site	Stubble treatment	Stubble at sowing 2009 (t/ha)		Change in soil water [W] (mm)	Plant population 2009 (plants/m²)	
		Behind [B]	3 m out [C]		Behind [B]	3 m out [C]
11	Incorporated with offset disc	4.7[D]		+19	70	84
	Mulched with Kelly disc chain	5.9[D]		+13	70	83
	Baled, mulched with Kelly disc chain	4.3[D]		+18	84	89
12	Grazed	12.6	7.5	+44	164	177
	Grazed, mulched Kelly disc chain	11.1	7.5	+48	178	193
	Grazed, burned	9.7	6.5	+41	188	212
13	Nil	11.3	5.3	+31	17	11
	Lightly grazed, harrowed	8.9	10.1	+56	11	21
	Lightly grazed, burned	9.0	3.1	+44	24	30
	Low harvest height, lightly grazed	9.8	4.5	+31	21	24
14	Grazed	12.1	3.1	+24	43	65
	Coolamon harrows, grazed	8.1	3.4	+25	43	53
15	Nil	9.9	5.5	na	184	202
	Baled	8.2	3.3	+29	166	196
	No summer weed control	9.0	5.1	+27	172	187
	Mulched with Brookfield disc chain	5.5	5.0	+14	191	214
	Mulched with Brookfield disc chain plus biological product	8.1	5.1	+29	196	207

[B] in the header trial, immediately behind the header
[C] 3 m to the side of the centre of the header trail
[D] average stubble load across whole plot
[W] change in available soil water from 0 to 60 cm depth between harvest 2008 and sowing 2009

populations in the treatments assessed. In the *baled and mulched with the disc chain* treatment weeds were very small at the time of assessment (early September).

At Site 13 the dominant weed was annual ryegrass. There were no weeds found in the untreated stubble or the grazed and late burn plot. There were 6 plants/m² in the baled and mulched treatment concentrated in the chaff rows behind the header. This would indicate that the late burn has had an impact on annual ryegrass seed numbers.

Table 13 Weed population at selected treatments and sites.

Site	Treatment	Weed population (plants/m²)
11	Incorporated with offset disc	4.8
11	Mulched with Kelly disc chain	3.4
11	Baled, mulched with Kelly disc chain	6.1
13	Nil	0
13	Lightly grazed, burned	0.1
13	Lightly grazed, harrowed	6.3
15	Mulched with Brookfield disc chain	2.2
15	No summer weed control	2.4

Poor crop establishment impacted on crop yield and reduced competition against weeds due to the hair-pinning at Site 13.

Table 14 Soil characteristics post-harvest 2008 for each on-farm demonstration site, 15–30 cm, 30–45 cm, 45–60 cm.
Note: this information is from demonstration plots, not from a replicated trial.

Site	Depth	pH	C	N	P	S	CEC
1	15–30 cm	5.8	0.51	10.0	5.1	17.0	14.00
	30–45 cm	6.2	0.39	9.1	<5.0	8.9	17.00
	45–60 cm	6.5	0.44	7.4	<5.0	4.6	17.70
2	15–30 cm	5.7	0.52	2.6	6.2	5.6	8.02
	30–45 cm	6.4	0.40	<1.0	6.1	5.8	10.10
	45–60 cm	6.7	0.39	<1.0	6.8	4.6	11.40
3	15–30 cm	5.6	0.36	5.4	10.0	8.9	6.35
	30–45 cm	6.1	0.25	5.4	6.8	7.1	6.88
	45–60 cm	6.9	0.17	2.0	6.7	5.5	8.43
4	15–30 cm	5.2	0.34	8.1	6.0	5.7	5.80
	30–45 cm	6.0	0.24	5.0	<5.0	4.3	9.11
	45–60 cm	6.3	0.21	1.2	6.5	3.1	12.00
5	15–30 cm	4.6	0.40	5.6	5.5	2.1	3.73
	30–45 cm	4.9	0.20	4.9	<5.0	<1.0	4.84
	45–60 cm	4.8	0.22	5.2	<5.0	3.1	11.40
6	15–30 cm	5.3	0.39	<1.0	11.0	13.0	5.98
	30–45 cm	5.6	<0.15	<1.0	5.6	9.8	6.27
	45–60 cm	6.0	<0.15	<1.0	18.0	11.0	9.13
7	15–30 cm	6.1	0.39	<1.0	5.3	3.9	13.30
	30–45 cm	6.9	0.21	<1.0	<5.0	9.3	20.30
	45–60 cm	8.0	<0.15	<1.0	<5.0	17.0	26.50
8	15–30 cm	5.8	0.36	<1.0	8.0	5.9	7.22
	30–45 cm	6.8	0.16	<1.0	<5.0	8.9	10.70
	45–60 cm	7.4	0.18	<1.0	<5.0	27.0	19.40
9	15–30 cm	5.1	0.38	4.8	6.7	3.2	4.74
	30–45 cm	5.7	0.33	2.0	<5.0	9.7	16.60
	45–60 cm	6.3	0.26	1.2	<5.0	14.0	18.90
10	15–30 cm	4.4	0.21	7.5	8.4	8.2	2.81
	30–45 cm	5.6	0.17	12.0	<5.0	9.2	5.78
	45–60 cm	6.2	0.20	7.5	8.4	7.8	9.33
11	15–30 cm	6.0	0.35	<1.0	6.6	3.2	8.82
	30–45 cm	6.7	0.29	<1.0	5.1	4.0	15.20
	45–60 cm	7.2	0.25	<1.0	<5.0	5.9	15.40
12	15–30 cm	5.0	0.50	8.7	6.2	10.0	6.14
	30–45 cm	6.3	0.22	2.8	<5.0	2.0	10.50
	45–60 cm	5.9	0.29	5.5	<5.0	2.5	8.47
13	15–30 cm	5.1	0.66	<1.0	6.3	3.6	3.68
	30–45 cm	5.9	0.36	<1.0	<5.0	5.2	7.74
	45–60 cm	6.1	0.25	1.0	<5.0	6.7	9.88
14	15–30 cm	4.9	0.33	21.0	9.7	17.0	2.64
	30–45 cm	5.7	0.30	17.0	<5.0	17.0	3.72
	45–60 cm	5.9	0.27	11.0	7.8	5.7	5.04
15	15–30 cm	5.4	0.50	2.2	7.0	9.3	6.54
	30–45 cm	6.1	0.41	<1.0	5.2	6.8	10.30
	45–60 cm	6.5	0.31	<1.0	6.5	3.3	11.20

pH 1:5 $CaCl_2$ N nitrate (mg/kg) S sulphur (mg/kg)
C Organic C (%) P phosphorus (mg/kg) CEC cation exchange capacity (meq/100 g)

Case Study 1

'Englefield Plains' Illabo

Property details: 4278 ha; average annual rainfall 546 mm; April to October rainfall 340 mm; target wheat yield 3.6 t/ha.

Key enterprises: annual winter crop (80%): 40% wheat; 30% barley; 30% canola.

Perennial pasture (20%) incorporating agistment livestock.

Soil type: red loam with some granite and some shale, small area of shallow soil over rock.

Typical crop rotation: wheat—wheat—barley—canola— wheat—wheat—barley—canola → some lucerne.

Tillage: no-till.

Seeding cultivator: Conserva Pak edge-on tine with parallelogram seeding boot and press-wheel set up for accurate seed placement, spaced at 304.3 mm (12 inch)

Ezi-steer (steering wheel fitted) steering.

Stubble management: cut as low as practical at harvest.

Mulch heavy cereal stubble and stubble crunch canola stubble in late summer.

Burn pre-sowing only when necessary to avoid issues with blockages at sowing.

Key drivers of crop choice: crop disease; crop yield potential; ability to manage weeds; season length.

The state of play in 2009

'Englefield Plains' Illabo, southern New South Wales is owned by REST Superannuation Company Trust Manager, Warakirri Pty Ltd and managed by Geoff Dale with David Cook, Assistant Manager. The property is primarily focused in annual winter cropping with 25% perennial legume pastures. The pasture phase has been included to aid management of herbicide resistant weeds and to boost soil nitrogen levels. The proportion of legume pasture is currently being scaled back in favour of annual winter crops.

On-farm demonstration at 'Englefield Plains', Illabo.

The cropping program is driven by yield, which in turn is influenced by crop disease, weed management and matching crop and variety to sowing time or season length. Managing crop residues is rapidly becoming one the biggest challenges facing Geoff and David. Dealing with stubble at planting time is a key area of the cropping system where improvements are required. Issues with blockages of the seeding cultivator need to be addressed.

Stubble management

Stubble management at 'Englefield Plains' begins at harvest. Crops are cut at the lowest practical height. Then in late summer the heaviest cereal stubbles are mulched using a flail mulcher with the aim of chopping straw into short lengths.

Geoff and David have trialled inter-row sowing as a solution to effectively sowing into stubble, however they run into problems when sowing across hillsides. The cultivator has a tendency to fall back into the previous year's furrows. This results in sowing back into the previous year's row of stubble and residue blockages.

Grazing stubbles is not part of stubble management on 'Englefield Plains'. Geoff sees no real benefit in grazing stubbles but a number of associated problems including:

- compaction of the topsoil, and
- removal of groundcover, especially if grazing occurs soon after harvest and groundcover is reduced for a long period of time.

Both of these factors then lead to reduced water conservation due to reduced infiltration and increased surface evaporation.

Weed management

One of the major challenges David faces with managing weeds in annual winter crops is controlling grasses in cereal crops, especially annual ryegrass and brome grass. However these weeds can be managed effectively with:

- attention to detail when it comes to boom setup and herbicide application technology; and
- the use of crop sequence and an occasional stubble burn.

Implications of stubble retention on crop health and the soil

Geoff and David are unsure whether retaining stubble will or won't impact on crop disease. The main concern is foliar diseases which can pass from the stubble of the previous crop to the current crop. Yellow leaf spot is one disease to be watched, but its impact is as yet unknown. Rarely has the disease been reported to cause yield loss in southern NSW however this may change with increased adoption of full stubble retention.

The Conserva Pak tine and press wheel assembly has a parallelogram design so the seeding depth of each tine is controlled by the press wheel.

Geoff says, "I think we can work around these [seeding and disease] issues for the potential benefits of healthier soils with greater water holding capacity."

Future opportunities and challenges

Geoff and David plan to improve their current seeding cultivator, the Conserva Pak, to work more consistently in thick stubble. At this stage they are not convinced that a disc seeder is the answer for their operation. They aim to trial some form of coulter in front of each sowing tine.

Ultimately the key is to move completely away from late stubble burning altogether and be able to reliably inter-row sow on hillsides—currently the seeder creeps into the previous years furrow.

Lack of soil moisture or inefficient utilisation of the rain that falls is a threat to the profitability of the current cropping system. Geoff believes the challenges associated with retaining stubble (potential crop disease, herbicide resistant weeds and seeding issues) can be worked through to achieve the potential benefits including healthier soil with greater water holding capacity.

Case Study 2

The Ingold Family, Dirnaseer

Property details: 2000 ha; average annual rainfall 525 mm; target wheat yield 3.5 to 4 t/ha.

Key enterprises: Annual winter cropping (60% total area): 50% grain only wheat; 10% grazing wheat; 10% undersown cereal; 10% barley; 10% canola; 5% lupins; and 5% oats.

Prime lamb enterprise (40% total area) supported by annual (10% area) and perennial (30 % area) pastures.

Soil type: red loam to red clay (some self mulching) and gravelly ridges. Key constraint is mechanical issues associated with gravely ridges and presence of large rocks.

Typical crop rotation: canola—wheat—wheat—barley—lupins—wheat—wheat—barley undersown with pasture → 4 to 6 years pasture. Some chemical fallow.

Tillage: no-till. Year one of inter-row sowing (i.e. will inter-row sow in 2010).

Seeding cultivator: Flexicoil bar fitted with Knuckeys tine and press wheel assemblies fitted with knife points, spaced at 305 mm.

Shared RTK 2 cm autosteer.

Stubble management: no or very light grazing of cereal, no grazing of canola or lupins.

Key drivers of crop choice: crop disease (especially cereal leaf diseases).

The state of play in 2009

Derek Ingold farms with his wife Susan, his parents John and Beverley and son Alex. They manage a mixed farming operation at Dirnaseer NSW, north of Junee, dominated by annual winter cropping and a prime lamb enterprise supported by perennial (lucerne) and annual (sub clover and annual grasses) pastures. Derek and his family are in the process of moving to a cropping system where they can inter-row sow using 2 cm autosteer on their sowing tractor. One of the key aims is to retain cereal crop residues without the challenges of blocking machinery at seeding time.

Stubble management

The Ingolds are grazing stubbles less and less. In 2008 only some of their cereal stubbles were grazed, and then only very lightly. It would be ideal to avoid grazing stubbles at all, and in 2010 this is their plan. The move to no stubble grazing is probably more of a change in mind-set rather than a large practical or management issue. To maintain current livestock levels a containment area for summer and autumn feeding will be implemented.

Derek has observed a number of issues with running sheep on stubbles over summer, even at low rates for relatively short periods of time. Derek has seen an increase in water run-off, and he believes it is associated with degradation of the surface soil structure. Grazing sheep also knock stubble down causing problems with trash flow at seeding.

Derek Ingold explains to field day participants how the Knuckeys tine and press wheel assembly operates to maintain uniform seeding depth.

Cereal stubble layer remains as groundcover under the following canola crop.

Weed management

Derek and Alex believe they have most weeds under control. They have no real problem weeds; however they are focused on reducing the risk of weeds developing resistance to herbicides. Many of their weed management decisions are based around managing that risk as well as reducing weed numbers.

The current move to increasing the levels of stubble retained is likely to cause a reduction in the effectiveness of soil-incorporated residual herbicides such as trifluralin.

Implications of stubble retention on crop health and the soil

Derek sees that stubble retention will bring more benefits than challenges. Insect numbers may increase, however the increase may be in beneficial species resulting in a more environmentally friendly cropping system. The reduction of stubble grazing should result in increased infiltration of water into the soil due to improvements in surface soil structure. More of the high-intensity summer rains will be stored in the soil profile and the stubble cover will reduce evaporation. Derek hopes the increase in soil water will not only result in more grain yield, but increased microbial activity and mineralization of soil nitrogen.

Future opportunities and challenges

One of the challenges Derek sees with the cropping system he is moving to (controlled traffic and inter-row sowing) is the inability of the header to effectively spread crop residues across the width of the header. Both Derek and Alex would like to have a header or system in place within five years that can properly spread straw.

Some of the other challenges facing the new cropping system are 'unknowns':

- What will happen to crop diseases in the new system? Will the cereal stubble increase the pressure of foliar diseases in particular? Will our current varieties stand up in the new system?
- How will the seeding equipment and inter-row sowing work when high yielding seasons return? Will it be effective in high stubble loads?
- How will soil incorporated residual herbicides be used effectively? Perhaps a strategic burn will have to be used to enable use of these herbicide tools. Will the weed spectrum change?

Case Study 3

Tony Lehmann, Illabo

Property details: 2300 ha; average annual rainfall 550 mm; April to October rainfall 300 mm; target wheat yield 4.0 t/ha.

Key enterprises: annual winter crop (65%): 67% wheat; 7% barley; 26% canola.

Perennial pasture (30%) and annual pasture (5%) supporting a self replacing Merino flock, and Merinos crossed to terminal sires for prime lamb production.

Soil type: red brown earth.

Typical crop rotation: wheat—wheat—canola—wheat—wheat—barley—canola.

Tillage: no-till.

Seeding cultivator: John Deere single disc seeder on 250 mm row spacing. Fitted with Aricks Wheels (residue managers). Also Flexicoil tine airseeder.

Stubble management: light graze over summer and keep weed-free using herbicide.

Key drivers of crop choice: prefer early sowing. Use varieties with a range of ideal sowing times so each variety is sown on time. Yellow leaf spot resistance in wheat.

The state of play in 2009

Tony Lehmann farms 2300 ha in the Illabo district of New South Wales with a focus on annual winter cropping and a significant sheep enterprise. Two thirds of the area is sown to annual winter crops based around wheat, with canola used as a break crop for weed and cereal disease management, and barley used to extend the cereal component of the rotation. Stubbles are lightly grazed with a focus on retaining ground cover on both stubble and pasture paddocks.

Tony invested in his disc airseeder four years ago and retained his tined airseeder, initially because he wasn't game not to have it. After four seasons he believes there are more pros than cons with the disc seeder. Tony says, "I still like to use a tine machine to bring new paddocks in – levelling, busting up tight bits and I don't like bare paddocks that blow in the summer. We work them fairly deep – six to eight inches and then take advantage of that to use a soil residual herbicide. I am sure sometime I may need a tine machine for rhizoctonia or similar control, or maybe even pasture cockchafer disturbance. Sowing pasture is still a bit of a concern with the disc machine, but maybe that's just the dry seasons?"

Tony Lehmann's John Deere single disc air seeder set on 250 mm row space has almost zero disturbance. The Aricks Wheel residue managers were added to clear straw from the path of the disc and reduce 'hair-pinning' of stubble at sowing.

Stubble management

Currently Tony grazes his stubbles lightly over summer and when needed, applies herbicide to control small summer weeds. Tony aims to retain ground cover on all his country with the aim of optimising soil moisture retention. Grazing stubbles takes the pressure off his pasture paddocks, allowing them to recover and spreading the grazing load. The stubbles enable Tony to better manage his sheep over summer, maintaining their body weight and

minimising the need to contain and feed them.

As well as these benefits Tony sees many drawbacks with grazing stubbles including:

- Tracks formed by sheep
- Stubble on ground causing trash-flow problems at sowing
- Compaction
- Spread of weeds
- Need for sound fences
- Paddock size to suit grazing compared to cropping efficiency.

In the future, Tony would like to be able to spread the crop residue evenly across the width of the header and leave all the stubble standing. He believes the best way to retain standing stubble is to inter-row sow. Currently his row space and stubble hair-pinning are limiting his ability to achieve this. He may have to move to wider row spacing and has added Aricks wheels in front of his disc seeding assemblies. The Aricks wheels have addressed the hair-pinning, although they are a bit more aggressive than the zero disturbance of the disc and will be expensive to run as they are high maintenance.

The issue of spreading crop residue across the width of the header is gradually being improved with chopper and spreader improvement made by header manufacturers but remains a challenge.

Weed management

The key weed management issue facing Tony's cropping program stems from the use of the disc seeder and the inability to incorporate residual herbicides. This places pressure on in-crop selective herbicides. It increases the importance of implementing alternate weed management tactics, such as sowing some paddocks after the first weeds germinate and using a knockdown herbicide. This is a very effective approach but not every season is suitable to control weeds in this way.

Implications of stubble retention on crop health and the soil

The increased level of stubble retention has reduced the weed number (both summer and winter weeds) and changed the weed spectrum. There also seems to be more cockchafers, earwigs and other pest insects. Hopefully on the plus side, there is also more worms and soil biology is greatly improved.

Joint Junee Reefs Top Crop Group and Farmlink Field Day participants inspect the on-farm demonstration in late July.

Future opportunities and challenges

Future plans for improving stubble retention with the cropping system includes the use of wider row spacing to enable inter-row sowing and the use of both the tine and disc system. It is unlikely we will be able to spread crop residues effectively to 12 m (40') which is a key issue to making the inter-row cropping system work. Levelling paddocks would improve the system which may mean the rotation starts with a cultivation.

One of the challenges with the stubble retention system including light grazing is the residue that is laying on the ground when it gets wet. This can cause hair-pinning and trash-flow problems at sowing time.

Once the challenges are overcome the benefits are endless and based around the ability to utilize smaller rainfall events and retain moisture in the soil for longer than in bare ground. This has the potential to enable more timely sowing, and result in effective germination and crop establishment on small rainfall events. Timely crop establishment then directly increases potential crop yield.

Case Study 4

Justin Roberts, Dirnaseer and Cootamundra

Property details: 1620 ha; Dirnaseer (930 ha)—average annual rainfall 575 mm, April to October rainfall 350 mm, target wheat yield 3.2 t/ha; Cootamundra (690 ha)—average annual rainfall 625 mm, April to October rainfall 400 mm, target wheat yield 4.0 t/ha.

Key enterprises: annual winter crop (45%): 60% wheat; 30% triticale; 10% lupins, field peas or canola. Seed production and marketing. Prime lamb enterprise based on composite ewes. Commercial ram breeding. 70 head breeding beef cattle herd. Livestock enterprises based on lucerne (400 ha), phalaris based perennial pasture (300 ha) and annual pasture (200 ha) including sub clover, murex medic, balansa white clover and ryegrass.

Soil type: Dirnaseer dominated by loam and clay loam. Cootamundra more variable with some areas of salt and shallow salt white clay subsoil, acid soils and heavy red clays. Areas of granite rocks.

Typical crop rotation: Dirnaseer: wheat—wheat—lupin or peas—wheat—triticale
Cootamundra: triticale—triticale—triticale—lupins—triticale undersown to pasture.

Tillage: direct-drill, mainly full cultivation at sowing. Some reduced-till: cultivate (scarifier) approximately 10% of fallow area each year eg after frosted wheat cut for hay or sometimes when coming out of pasture phase.

Seeding cultivator: full cut combine with cultivating tines at 205 mm row spacing with finger harrows; single disc combine for pasture and canola.

Stubble management: grazed.

Key drivers of crop choice: soil type (pH, salinity), weeds, proximity to silos and livestock.

The state of play in 2009

Justin Roberts farms two properties with his wife, Kylie and parents Hugh and Jenny. One farm is near Cootamundra and has quite variable soil ranging from salty, heavy clays to lighter, acid loams and rocky, granite outcrops. The soils and topography limit this property to grazing and triticale and lupin production. The lucerne pastures and wheat-based annual winter cropping is on the Dirnaseer property.

The Roberts family run a diverse business across the two properties, with a composite ewe flock producing up to 3500 prime lambs sold directly to Woolworths each year, a breeding herd of 70 beef cattle, annual and perennial pastures, annual winter crops including dual purpose or grazing cereals, a seed business and a small ram breeding enterprise.

Due to the size of the cropping enterprise, the diversity of his properties and the hills and rocks, Justin has kept to using a combine for seeding. He uses a John Deere combine with cultivation tynes fitted most of the time for sowing the cereal and pulse crops. He uses a 1964 model single disc combine to sow pasture and canola.

Weeds and soil type, primarily pH, are the key drivers of crop choice. Justin and his father have been liming country for years but it is still more lucrative to grow acid tolerant crops such as lupins and triticale on some paddocks, particularly the Cootamundra country.

On the better cropping country, management of annual ryegrass is a focus when selecting crop type. If there is annual ryegrass in the paddock it will be sown to lupins or field peas, or sown down to legume based pasture so the seed bank can be reduced. If there is

not an annual ryegrass problem, or any other grass weed problem, successive wheat crops may be grown.

Other factors that impact on which crop is grown include proximity to storage silos for lupins and triticale, and proximity to livestock or pasture paddocks so grain can be stored as close as practical to the paddock where it is grown and the paddock where it is likely to be fed out.

Cultivation still plays a part in the Roberts' farming system. Approximately 105 ha of the farm area is cultivated each year. For example a paddock may be fallowed by herbicide and cultivation when coming out of a pasture phase or a paddock that has been cut for hay may be cultivated prior to the next crop. This summer Justin is trialling a number of cultivation practices after observing excellent crop yield results on some local paddocks that were deep ripped. Justin has trial strips in a paddock using the following cultivation methods:

- Scarifier
- Deep ripper
- Offset disc
- Aerator
- Scarifier plus aerator
- Offset disc plus aerator

Justin's aim is to maintain the fallow weed control and increase infiltration of rainfall events into the soil and reduce run-off.

Stubble management

Crop stubbles are cut slightly lower than they were 10 years ago and then they are grazed at a moderate level, always aiming to retain full ground cover. Herbicides are applied to summer weeds that sheep don't graze such as melons, black grass and heliotrope, and cattle are also used to help control these weeds. Livestock are moved to laneways or annual pasture paddocks after significant rainfall events over summer to minimise compaction and damage done to the topsoil.

Justin and Hugh are happy with the way they manage their crop stubbles as their focus, and more importantly income is derived from the livestock enterprises. The grazing enables them to sow through the remaining trash without blockages in the combine and is critical to managing the perennial pastures and optimising overall stock carrying capacity (increased DSE per ha). It is important to remove the stock from the lucerne for a period over summer and allow it to flower, store carbohydrates and as a result be more productive, and also to let the phalaris based pastures grow out. Grazing the stubble also ensures adequate groundcover can be retained on the hill country to reduce run-off and the risk of erosion.

Weed management

Weeds, in particular annual ryegrass, are managed in both the cropping and pasture phases using herbicides and grazing. Justin says, "Controlling annual ryegrass is almost more critical in the pasture phase than the cropping phase. I clean up grass weeds in the lucerne with a spray-top in spring for two consecutive years prior to going into the crop phase. This takes a lot of pressure of the grass control in the wheat. It also means we can grow more wheat crops in a row, which also means more income."

The stubble grazing enables Justin to use residual herbicides in his annual ryegrass control program.

Future opportunities and challenges

In the near future Justin would like to update his combine to a wider combine (end tow) with improved trash flow capabilities or a disc undercarriage. This year he will invest in an steering wheel auto-steer hooking into the Dirnaseer tower, an RTK system developed by a group of 15 local farmers.

Justin is positive about the future of farming and sees investment in land to increase the scale of his business as a forward move.

One threat he sees is what he terms 'urban involvement' – the control and legislation enforced on land manages by others who have little idea how to manage a farm business or the land being farmed. But Justin says, "There are opportunities everywhere, some on-farm, some off. It is important to keep your mind open to ideas and opportunities, but remember that profit is the key, wherever you invest!"

Case Study 5

Michael Howard, Ariah Park

Property details: 1800 ha; average annual rainfall 450 mm; April to October rainfall 350 mm; target wheat yield 2.5 t/ha.

Key enterprises: annual winter crop (35 %): 65% wheat; 10% barley; 10% oats; 15% lupins. A mix of perennial, annual and native pastures (75%) supporting a self replacing Dohne flock (meat and wool production) and a beef cattle enterprise.

Soil type: a wide range, from gravely sands on iron bark ridges, through to loam, clay loams, and heavy self mulching clays in yellow box gullies. Predominant soil type is red clay loam.

Typical crop rotation: once pasture reaches less than 70% ground cover paddock goes to crop phase: wheat—lupins—wheat—barley or oats—back to pasture phase (lucerne or ryegrass/sub clover mix).

Tillage: no-till.

Seeding cultivator: Horwood Bagshaw Stubble Master chisel plough with cast tines and narrow points at 300 mm row spacing; Agmaster (plastic) rotary harrows.

Stubble management: all grazed over summer.

Key drivers of crop choice: low soil pH; weed species and population determines the choice between cereal and alternate crop; yield stability is key factor for choosing wheat (and other crop) variety (Janz remains a dominant variety and an excellent all round performer across seasons and soil types compared to recently released varieties tested on farm); rainfall timing—wheat must be sown at beginning of sowing window so late break will lead to increase in barley or oat area.

The state of play in 2009

Michael Howard farms 1800 ha of quite varied country at Ariah Park with his parents Margaret and Rex. Together they grow between 500 and 800 ha of annual winter crop each year, with the balance of the area sown to either lucerne or ryegrass and sub clover, and about 300 ha of native pasture in shelter belts, timber block and iron bark ridges.

Michael manages a wide range of soil types, from heavy self mulching clay through to gravely sands, but low soil pH (acid soils) combined with high aluminium levels (up to 15% total cations) is the most limiting factor. The Howards have an ongoing program where at least one stubble paddock is limed each year.

In the recent run of poor seasons Michael has started some of his crop phases with a barley crop direct drilled directly into the pasture. This is then grazed and sprayed out with non-selective knockdown herbicide in early spring. This has been very effective at reducing the weed seed bank and provides winter grazing and a standing hay crop for summer grazing. Spraying the crop out in early spring is equivalent to a good fallow.

Stubble management

Stubble management at the Howards can be described in a single word – grazing. Livestock have been the main income stream during the past five or six years, and like many farms in the region, they have become the focus of the farming system for Michael and his parents. Although they would prefer to graze the stubble lightly to preserve the soil condition this has not been possible in recent years. In seasons with adequate spring rainfall, the non-crop area would adequately supply sufficient stock feed for most of

summer, with only light grazing of stubble necessary.

Michael has no problems sowing though his stubbles as the tynes on the Horwood Bagshaw cultivator are well spaced and trash flows through easily.

Michael has noticed there is less stubble to manage when crops are grown at 300 mm row space compared to the old 180 mm row space. He has considered sowing his wheat on a narrower row space to increase the amount of stubble, however the logistics of that are not so simple (or cheap). It would then be ideal to sow lupins (or canola) at 300 mm row space into a higher stubble load.

Weed management

Grazing stubbles does have an impact on weed levels. In particular the ability to manage summer weeds in stubbles is one key advantage of grazing stubbles. As for winter weeds, Michael uses crop choice as a key to implement weed control tactics such as delayed sowing and knockdown herbicide application, and selective in-crop herbicides.

Implications of stubble retention on crop health and the soil

Although Michael grazes the stubble quite heavily, he always aims to retain more than 70% ground cover. He says, "Keeping ground cover helps the soil microbes and the whole soil system to responds more rapidly to rain. Infiltration is better with stubble cover – more of the water goes into the soil rather than running off into dams."

Future opportunities and challenges

In the near future, Michael plans to invest in a GPS autosteer system to address operator fatigue and reduce input costs. He understands the benefits of tramlining and controlled traffic farming but feels that those benefits are not likely to be realised when

Low harvest height is one treatment used at many sites aimed at improving trash flow at sowing.

livestock are going to be such a key part of the cropping system.

Press wheels are also on the shopping list as an alternative to his rotary harrows, improving seed-soil contact and crop establishment.

Michael has looked with interest at disc machines and the results being achieved around the district but says, "When the heavy soils get wet we would not be able to sow them, and the investment over the area of crop we grow would be too large to justify."

Michael is positive about the future of the food and fibre industries. He says, "The global food shortages in 2007 were just a wake up call. The world population is growing and everybody has to eat. People will spend there last dollar on food rather than luxury items. I think there is a strong future for food and fibre production."

He also thinks there is a major challenge facing food producers globally. "Phosphorus is a world wide issue—both supply and cost. No-one seems to have worked out what to do as an alternative to mining phosphorous, and there doesn't seem to be much concern. It will be a big issue for Australian producers who are farming such phosphorous-poor soils."

Case Study 6

Mukoora, Ardlethan

Property details: 8700 ha; average annual rainfall 450 mm; April to October rainfall 332 mm; target wheat yield 3.5 t/ha.

Key enterprises: annual winter cropping (90% total area): 55% wheat; 30% barley; 15% canola; chemical fallow (10% total area).

Soil type: large range, from sandy loam to self mulching clay. Limitations associated with the soil types include: wetting of heavier (higher clay content) soil types in dry years; subsoil sodicity in heavier soils which reduces root growth into subsoil and plant available soil moisture.

Typical crop rotation: fallow—canola—wheat—wheat—barley—back to fallow.

Tillage: no-till.

Seeding cultivator: Horwood Bagshaw airseeder with knife point tines spaced at 262 mm; press wheels; 2 cm RTK autosteer, .

Stubble management: leave standing, no grazing, no weeds. Stubble mulch or crunch on a needs basis if there is a conceived problem for sowing operation.

Key drivers of crop choice: market and seasonal forecasts for crop ratio. Variety choice related to yield, quality and disease expectations.

The state of play in 2009

'Mukoora' Ardlethan New South Wales, is owned by REST Superannuation Company Trust Manager, Warakirri Pty Ltd and managed by Stephen Buchanan with Evan Lord, Assistant Manager and John Tomlinson, Cropping Assistant. Together they operate a very large and efficient annual, no-till, cropping operation.

Stubble management

Stubble management is currently driven entirely by the need to conserve moisture for each crop. The aim at 'Mukoora' is to leave all crop stubble standing. There is no livestock on the property and it is believed that grazing stubbles is extremely damaging to the soil, particularly the top 10 cm which becomes compacted and loses all structure. There are no benefits associated with grazing crop residues.

Weed management is a very important component of stubble management over summer. Weeds can become a huge problem during the sowing operation, causing blockages, especially when straw is damp. For this reason weeds are not tolerated in stubble on 'Mukoora'.

Stubble load 12 months after harvest, at the end of a fallow period for mulched with prickle chain treatment (left) and nil treatment (right). Stubble cover during the fallow is important to reduce the risk of wind erosion and optimise soil water storage.

If the biomass of crop residue appears to be likely to cause trash-flow issues at planting, mulching or stubble crunching is used to break stubble into small pieces and improve flow through the cultivator.

Currently canola stubble causes the most problems with trash flow. Canola stems are large and branched due to the low plant population (25 to 30 plants/m^2) targeted in on 'Mukoora'. Planting a crop through this residue often causes trash-flow problems. In general, this is not a common problem in the region.

In future Steve would like to be able to plant through any residue level and leave all stubble untouched and standing.

Weed management

Grass weeds in cereal crops is the key weed management issue facing Stephen. The full stubble retention system is aided at harvest by cutting crops slightly lower than normal harvest height. However, this can cause more self-sown weeds in paddocks because weed seeds end up in the header and can be spread widely when thrown out of the header with the chaff and straw.

Implications of stubble retention on crop health and the soil

Stephen says, "Insect management in our environment so far has not been a problem and insecticide usage is limited. The biggest issue is telling the local fertilizer supplier we are cutting back on fertilizer inputs due to improved soil health."

Future opportunities and challenges

The Mukoora management team has thought about switching to a disc seeding machine to improve stubble handling and reduce soil disturbance at sowing. At this stage they are not convinced the disc machines available are robust enough or cost effective for the scale of the operation.

Stephen says, "At this stage, one very simple change that may be made is the use of a shorter length knife point. Other ideas being contemplated are using a parallelogram planting assembly and a wider machine used at a slower planting speed. The current

The Horwood Bagshaw airseeder used at Mukoora is set on 262 mm row space and is open to optimise trash flow at sowing.

airseeder is doing the job for us but we are always open to something better. We haven't really seen anything that I would say would do a better job as yet."

Another challenge facing Stephen and his team is control of grass weeds. They are always on the lookout for alternate tactics to control these weeds. Stephen believes in more use of non-selective knockdown of grass weeds in-crop, perhaps with something like a detector spray system. The other option could be a wiper system for grass weeds at a later plant maturity.

On threats and opportunities Stephen says, "There are always threats to profitability, at many levels. The important thing is how you manage those threats and what risk management tools you have in place. Farmers have to plan better and not be so focused on relying on the Government. But obviously getting paid for sequestration of carbon is where the big opportunities lie.

"We as farmers generally get bogged down in the negatives of our industry. We hear so much about global warming, the financial crisis, drought and the loss of 'The Single Desk' that we lose focus on the really good things that are happening in the industry. All these negatives we have no control over, but we consume so much energy worrying about them.

"The good things that are coming out of our cropping systems due to these outside influences are really positive. These are the things that should be exposed to the community at large. This change we experience all the time is what makes us more creative and better farmers. We have to question a lot more about how to make our cropping systems more sustainable into the future. I believe this is what makes the industry so good, because we are always trying to adapt to adversity."

Case Study 7

Ian Sherwood, Ariah Park

Property details: 1200 ha; average annual rainfall 450 mm; April to October rainfall 350 mm; target wheat yield 2.4 t/ha.

Key enterprises: annual winter crop (65%): 65% wheat; 5% barley; 5% oats; 10% canola; 15% lupins. Annual pastures with some lucerne (35%) supporting 500 self replacing 1st cross ewes and 40 breeding beef cattle.

Soil type: red loam and heavy grey clay.

Typical crop rotation: continuous crop on some paddocks or long periods of crop followed by 4 to 8 years pasture and grazing cereals depending on seasonal conditions.

canola—wheat—wheat—lupins—wheat—wheat—lupins—wheat—barley.

Tillage: no-till.

Seeding cultivator: John Deere chisel plough with knife points and press wheels on 305 mm row spacing for past 18 years.

Stubble management: light graze over summer and keep weed free using herbicide.

Key drivers of crop choice: weed population; forecast commodity price and carry-over grain already on farm.

The state of play in 2009

Ian and Trudy Sherwood run a diverse mixed farming operation under lease and share farm arrangements west of Ariah Park, New South Wales. Ian has been sowing his crop at 305 mm or 12 inch row spacing for almost 20 years and had been retaining stubble and using no till practices for the same time. The only time Ian cultivates is when paddocks are coming out of a long term pasture phase. He likes to lightly scarify them to open them up and allow the rainfall to infiltrate the tightly packed soil.

Ian crops some paddocks on a continual basis while others have a reasonably long pasture phase before going back into a long crop phase. Grazing cereals including winter wheat and oats are used to fill the winter feed gap and the oats is often cut for hay and the grain used to supplement feed on-farm. Crop choice is largely dependant on the weeds present in the paddock, but also on commodity process and what grain is already on hand from the previous harvest.

Stubble management

In Ian's words, "Stubble is king! If you want moisture for next year you've got to have some stubble cover." Ian begins his stubble management at harvest. In years when the crops grow to an average height (not the past run of seasons) he will cut them lower to reduce the maximum length of stubble. He also has chaff spreaders fitted to his header to help spread the residue as uniformly as possible across the width of the header.

All his stubbles are then grazed lightly, and where possible removed to laneways or ley paddocks after significant rain events. Ian doesn't use the grazing to manage stubble weeds although they do have some affect. He keeps the stubble weeds under control with herbicide as necessary.

Ian has been researching the use of biological style farming and methods of increasing the rate of stubble breakdown in his relatively dry environment. He has found that to increase rates of breakdown stubble needs to be knocked down and in contact with the soil, preferably with a light mechanical incorporation, and there needs to be a good supply of nitrogen, phosphorous and sulphur. This however creates problems with

The on-farm demonstration suffered from extreme moisture stress during spring in 2009. There was also nitrogen tie-up observed in chaff rows behind the header (see the pale yellow patch of crop just above the white peg in the foreground).

nitrogen tie-up and challenges with trash flow at seeding.

Stubble grazing has become less important in recent years as stock number has been reduced, but still remains an integral part of the farm business. Ian believes the only benefit gained from grazing stubble is the stockfeed. On the flip-side, grazing makes the soil hard which can reduce infiltration and the stock bury the weed seeds resulting in uneven and repeated germinations through the season.

Weed management

Grasses are the key weeds – barley grass, annual ryegrass and some herbicide resistant annual ryegrass. Cape weed and Paterson's curse used to be a problem but they seem to be under control or perhaps the recent run of late breaks and tough springs has changed the weed spectrum. Wireweed always seems to be around but it us not a huge problem to manage.

Ian doesn't think stubble management has much of an impact on his weed or insect management. He hasn't used an insecticide for many years because he hasn't had a real need and he likes to keep the beneficial insects alive.

Stubble, particularly lupin stubble can be a problem when using a residual herbicide such as trifluralin in the following year, so Ian has to plan ahead with his weed control program.

Implications of stubble retention on crop health and the soil

Ian would love to see more stubble with the aim of increasing the biological activity in the soil. This has been a challenge during the past six to eight dry years with dry matter production greatly reduced compared to the 1990s. Ian has noticed with his wide row spacing (305 mm) there is never as much straw as there is with narrower (175 to 225 mm) row spacing. But that is the only down side of the wider rows.

Future opportunities and challenges

Ian sees the next step in his system would be RTK 2 cm autosteer to enable inter-row sowing, although he has hesitation over the ability for the airseeder to track accurately on undulating country. He is also keeping an eye on the results of using liquid fertiliser (phosphorus), a system where micro nutrients can easily be added fine tune the nutritional need of the crop.

Biological farming is one area that Ian sees a future opportunity and a means to improve the sustainability of his farming operation both environmentally and financially. "I am already using a bit of rock phosphate which is not rapidly tied up like the phosphorus in high analysis fertiliser but is slow to become available to the crop. It is a long term approach which makes testing and seeing results harder than with more conventional changes to the system."

Ian is also interested in biological agents promoted to increase the rate of stubble breakdown but has found it hard to get solid trial results to help him make a decision on which product to try.

"The cost of inputs [machinery, fertiliser and chemicals] and the ability to get a fair price [for our commodities] is a huge challenge facing Australian farmers. We seem to be an able to import food products at a lower price than we can produce them for."

On a more positive note, "There is a big future for biological farming – to grow healthy foods full of goodness. I hope to enjoy farming more than I have over the past couple of tough years. With a couple of good seasons and a bit of income I will be able to make the most of the opportunities out there."

Case Study 8

Peter Campbell, Pleasant Hills

Property details: 1400 ha; average annual rainfall 525 mm; April to October rainfall 375 mm.

Key enterprises: annual winter cropping (80%): 45% wheat; 15% triticale; 30% canola; 10% albus lupins. Annual pasture (10%) and perennial pasture (10%) supporting a self replacing Merino flock and prime lamb enterprise from Merinos joined to terminal sires. Seed production.

Soil type: approximately half red brown earth and half yellow podzolics on lower country (both duplex soils with loam topsoil). All acid, lime when pH_{CaCl_2} is less than 4.9.

Typical crop rotation: canola—wheat—wheat or triticale—lupin or canola—wheat—wheat undersown.

Tillage: no till, minimal disturbance.

Seeding cultivator: John Deere single disc seeder on 190 mm row spacing with furrow closers and press wheels. Fitted with Aricks Wheels (residue managers).

Stubble management: strategic light graze some.

Key drivers of crop choice: weeds.

The state of play in 2009

Peter and Alison Campbell farm 1400 ha in the aptly named Pleasant Hills district west of Henty, New South Wales. Under a liming program to address the soil acidity the soils pose no limitation to production. The business is a typical mixed farming operation, with annual winter cropping, a small seed production business and a livestock enterprise based around Merinos and prime lambs.

The Campbells have been direct drilling since 1984 and have been retaining stubble for about 15 years. During that time they have seen marked improvements in soil structure. They also have an active tree planting program in place.

The lucerne pasture makes up about 10% of the farm area and is used to fatten prime lambs which are sold in March or April. A small area of grazing triticale is sown in early April to get some early feed and allow the lucerne and annual pastures to get away.

Annual clover (arrowleaf or bladder) is sometimes sown in the middle of the crop phase if the nitrogen status needs lifting or grass weeds need controlling. It is sown in April, used for winter grazing then winter cleaned before being shut up to grow dry matter and fix nitrogen.

The 'crop' is then sprayed out in spring and fallowed over summer for the next winter crop.

Stubble management

Stubble is used to support the adult sheep flock over summer, however grazing is quite strategic and well managed. Peter says a light graze equates to approximately 500 DSE on 30 ha for two weeks. The first paddocks to be lightly grazed are those going back into crop then those going into annual pasture.

Canola stubbles are not grazed and lupin stubbles are very lightly grazed with young sheep. Sheep are removed when raised dust is observed. Sheep are also removed after rain. Once the stubble paddocks are exhausted, usually in very late summer they are moved to two 8 ha sacrifice paddocks and hand fed.

Peter has tested many mechanical methods of stubble management including stubble mulcher, Coolamon harrows, and residue collection directly from the header but none

have proved satisfactory and they are too labour and machinery intensive. He has settled on the use of light grazing, the disc seeder and Aricks residue manager wheels (when required) as his preferred stubble management method.

This year Peter upgraded the spinners on his header to achieve better spread of residue across the width of the machine. He also has a set of Aricks Wheel residue managers which he can use to improve seeding depth control when stubble loads are heavy. He doesn't use them on every paddock and only in cereal stubbles.

Weed management

Weed management is a key focus for the Campbell's mixed farming operation. Annual ryegrass is the major weed. Other weeds include toad rush, some broadleaf weeds (cape weed, wild radish) in a few paddocks and wild oats. A focus on weed control occurs in the:

- Last year of the pasture phase
- First canola crop when Roundup Ready® canola is grown to get good control
- Canola later in the rotation is Clearfield® or triazine tolerant technology depending on the key weeds being targeted.

Light grazing (compared to heavy grazing) helps to keep the weed seeds on the soil surface which seems to make them easier to control and reduces their ability to germinate and become established. This is also aided by the use of the disc seeder.

Implications of stubble retention on crop health and the soil

One of the risks of retaining cereal stubble is the carryover of foliar diseases such as yellow leaf spot. However Peter explains "Foliar fungicide is cheap and can be applied with early post-emergent herbicide or on the fertiliser so it is not really an issue".

Rhizoctonia can be an increasing problem when using a disc seeder and the lack of soil disturbance allows the fungal hyphae to spread in the soil. For this reason Peter uses Dividend® on all his cereal seed.

Peter has also noticed "You have to be a lot more on the ball with your weed control when you are keeping your stubble, particularly with limitations full stubble retention places on residual herbicide usage.

"The benefits of retaining stubble are just so great" Peter reports. "Retaining stubble really encourages the soil biota and there seems to be more worms—they are a good indicator of soil health!"

Peter and his soils adviser have noticed a significant trend in increasing nitrogen (N) levels measured by deep soil N testing over the past 15 years. This coincides with the move to stubble retention and direct drilling in 1984 then to no till.

Future opportunities and challenges

Peter and Alison feel they have finally got to where they want to be with there farm environment as it is slowly but surely improving. Peter would like to get his yield monitoring organised and adopt variable rate fertiliser application. He is now soil testing in zones rather than being constrained by fences and plans to spread urea and perhaps lime by zone.

Some of the challenges of retaining stubble have been the capital cost of machinery and the increased time required for repairs and maintenance – although Peter admits the time spent maintaining the disc seeding machine is less than he first thought.

Cost of production and the weather are threats to the business with freight rates of grain to port becoming more and more important. Minority lobby groups are also a threat to agriculture, imposing changes to management and running scare campaigns which affect markets, their arguments often based on emotion rather than fact.

Peter believes we are already adapting to climate change and any emissions trading scheme will simply be another tax on farmers.

On a positive note, the world food shortage will sure up demand, and price volatility can be used as an advantage by using forward pricing. Peter says "Farming keeps the brain ticking over to keep on top of things!"

Case Study 9

Andrew Newton, Walbundrie

Property details: 1100 ha; average annual rainfall 525 mm; April to October rainfall 330 mm; target wheat yield 4.5 t/ha.

Key enterprises: annual winter crop (70%): 67% wheat; 33% canola.

Perennial pasture (30%) lucerne based, with annual species (sub clover, Persian clover) supporting a self replacing Merino flock plus some terminal sire over Merino for prime lambs.

Soil type: red loam with some clay loam to clay. Not limiting production.

Typical crop rotation: pasture 4 to 5 years—canola—wheat—wheat—canola—wheat—wheat undersown with lucerne, sub clover, some perennial grasses used.

Tillage: no-till.

Seeding cultivator: AgrowDrill combine with Flexicoil tynes, knife points and press wheels.

Stubble management: all stubbles grazed moderately to maintain 70% ground cover.

Key drivers of crop choice: weed and cereal disease management, particularly take all.

The state of play in 2009

The Newton family farms 1100 ha of mostly arable red loam in the Pleasant Hills, Alma Park district of southern NSW west of Henty. The family team comprises Andrew, his parents Max and Allayne, and his brother Ross, an absent partner who works as an agronomist but is quite involved with decision making and assists at busy times.

The Newtons crop approximately 70% of their farm each year and run a self replacing Merino flock on the four to five year pasture phase of the rotation. The Merino ewes are joined to Merinos for six weeks, after which they are covered with a Poll Dorset ram. This is an effective way to improve the lambing percentage of the flock, resulting in about 10% prime lambs, providing an alternate income stream.

Andrew is regularly updating his combine to improve trash flow and accuracy of seeding depth. Last year he changed the tynes to Flexicoil tynes with knife points, increased the row spacing from 180 mm to 280 mm and added press wheels. These modifications aimed to increase trash flow and improve seed-soil contact and crop establishment.

The Newtons use a tram-track system with permanent tracks for in-crop operations such as spraying and spreading. They use a 4.5 m combine and 18 m boomspray (a four to one system). Four years ago they employed a contractor using ±2 cm accuracy GPS to mark out tracks every 18 m to suit the boomspray. Using an Ezi Steer in the sowing tractor and the wheel track tynes removed the track runs are sown first. The three runs in between each track-run are then filled in with all tynes sowing.

Weeds and cereal disease are the key drivers of the crop choice on this property. Andrew and Max have developed a reliable rotation using canola as a break crop and try to avoid growing any more than two wheat crops in a row. Approximately 40% of their wheat crop is grazing wheat which is usually the first wheat crop after canola in the rotation. This allows them to sow the grazing wheat early with confidence, knowing the grass weeds, such as wild oats and annual ryegrass, are under control. A non-selective knockdown can be used on the grain only wheat crops if needed.

Andrew utilises Clearfield® and triazine canola when chasing specific weeds such as silver grass or wild radish. He would be happy to adopt genetically modified crops or varieties in the future if there was a clear management or yield advantage.

Lupins used to feature in the crop rotation but Max found the price and yield fluctuations made them more risky than using canola as a break crop. The ultimate decision to drop them and triticale from the system was based on economics.

Stubble management

All stubbles are grazed to a moderate level. At least 70% ground cover is maintained at all times. Grazing stubbles is an important component of the grazing enterprise for Max. The advantages include keeping most summer weeds to a manageable level and allowing the lucerne to recover from spring grazing. Summer weeds are managed with herbicide application when needed.

Both Andrew and Max realise that the sheep do some damage to the soil. Grazing stubbles and winter cereals does compact the topsoil, but their combine limits the amount of stubble they can sow through. The last stubble burning was in 2005, the last good season they have had. Max wonders how they will go sowing though the stubbles of 4 and 5 t/ha cereal crops, but hopes they might have the opportunity soon to at least try!

Weed management

Weed management is a continual program starting in the pasture phase. Each year the pasture paddocks are winter cleaned with a spray/graze operation targeting annual grass weeds including annual ryegrass, silver grass, barley grass and wild oats and some persistent broadleaves including wild radish, cape weed and Paterson's curse.

In the final pasture year and as needed in other years, an insecticide is used post sowing to reduce red legged earth mites and blue oat mites. Strategic grazing is also used in the pasture and stubbles to manage weed numbers and weed seed set.

The removal of stubble burning from the cropping system is impacting on weed management. The cool burn was quite effective at reducing the weed seed number although it was by no means totally effective. At this stage the poor seasons (low stubble levels) and wide row space mean the residual soil applied herbicides are still effective. But the Newtons are aware that this may change when crop residue levels increase after a 5 t/ha crop.

Implications of stubble retention on crop health and the soil

Andrew is happy with the direction their management is heading and the improvements they are seeing. Andrew says, "The soil just seems more friable with a better seed bed. When I dry sow it comes up beautifully- not all cloddy the way it used to. I think it is the stubble retention and the zero till which we have been doing for quite a few years now. You are able to find worms when you dig around in the paddocks."

Future opportunities and challenges

Andrew's ultimate goal is to move to a full controlled traffic farming system with permanent tracks for all operations including the header, using 2 cm GPS autosteer and inter-row sowing. The aim would be to reduce the issues with stubble retention in high yielding years and manage compaction caused by machinery traffic.

Andrew's five year plan is to replace the combine, which is a limitation to his current cropping system, with an airseeder fitted with a parallelogram tine system and press wheels. He is unsure about a disc machine and believes it would limit the use of residual herbicides such as trifluralin and may not be as successful with dry sowing. The extra capital expense for a disc machine over a tine machine is hard to justify over the size of his cropping program.

Both Andrew and Max believe climate variability and commodity prices are two of the big risks facing their farm business. Andrew feels, "We are just taking all the hits at the moment. Grain marketing is becoming more and more important and we need to keep improving our skills."

On a more positive note, Andrew looks back to the 1980s remembering the bare paddocks and dust blowing —something that happened each and every summer. Andrew says, "The environment on our farm is improving all the time—with direct drilling, zero till, stubble retention, use of lucerne and tree planting." Max chimes in, "There are many more trees on the farm now than when Dad took it up in 1939!"

Case Study 10

The Scholz Family, Culcairn

Property details: 1670 ha; average annual rainfall 600 mm; April to October rainfall 386 mm; target wheat yield 5.0 t/ha.

Key enterprises: continuous annual winter crops on the arable country and breeding beef cattle based on a combination of annual and perennial pastures and lot feeding.

Soil type: mainly red/brown earth (loam) with gravely ridges and grey clay creek flats. The gravely ridges and ligter country has limited water holding capacity. The majority of the country is acid and is on an 8 to 10 year liming cycle.

Typical crop rotation: lupin—wheat—canola—wheat—wheat.

Tillage: no-till.

Seeding cultivator: John Deere ConservaPak tine/presswheel parallelogram airseeder; 305 mm row space; RTK 2 cm autosteer.

Stubble management: very light graze or no grazing; leave majority of stubble standing and inter-row sow.

Key drivers of crop choice: crop nutrition (e.g. hard wheat variety after break crop); use crop choice to aid weed and herbicide resistance management.

The state of play in 2009

Murray Scholz farms with his wife Emma and parents Barry and Elaine between Culcairn and Henty in the so called 'safe' country of southern New South Wales. His high rainfall cropping produces large quantities of stubble which has been turned into an asset in more recent years, rather than the nuisance it was in the past. Over the past three years Murray and Barry have moved to 305 mm row spacing and inter-row sowing with the chief aim of retaining cereal stubble and avoid the need for stubble burning.

Murray is excited with the results and how well the inter-row sowing has worked on his undulating to hilly country. Barry is perhaps a little more sceptical and both are waiting to see how well the seeding system will work when sowing into the stubble of a 5.0 t/ha wheat crop.

The Scholz's introduced barley into their program in 2009. Adding barley to the crop rotation has the following advantages.

- Handles low rainfall spring conditions quite well
- Later sowing than main season wheat allows a good knockdown of weeds prior to sowing
- Relatively cheap to grow.
- Another cereal reduces the risk of crop failure by increasing the ratio of cereal to break crop.

In addition to the continuous cropping on the arable country, the Scholz's run a 200 head beef cattle breeding enterprise utilizing the paddocks with large areas of trees or rocky ridges. The arable parts of these paddocks are sown down to either perennial species (including lucerne, phalaris and fescue) or annual species (subterranean clover and annual grasses).

The seeding depth of each tine is controlled by the press wheel attached to it in the Conservapak parallelogram design.

Stubble management

Stubble management starts at harvest with all cereals cut at 300 mm height to aid trash flow at seeding. Soon after harvest cattle are moved onto cereal stubbles at a low stocking rate (10 DSE) for a period of two to three weeks. This works theoretically but in drought years when the perennial pastures need more time to recover and feed is short grazing will be extended. Murray and Barry aim not to burn cereal stubble but if the residue looks like it will be a trash flow issue at seeding they will burn just before seeding. They haven't had to burn since they have been inter-row sowing but they haven't grown a five tonne crop either, so time will tell.

Grazing stubbles is important to the overall business, utilizing the resource (roughage for cattle) adding to the value of the cropping program. Grazing stubble also takes the pressure of the pastures, allowing the perennials to get away and provide valuable feed during autumn.

Murray doesn't see a huge problem with grazing stubble as long as it is light. When the cattle are on the stubble for longer than desired they knock down stubble causing problems with trash flow at seeding and also powder-up the topsoil which can blow.

Weed management

Weed management is a key driver of what happens within the cropping enterprise. Crop sequence and variety choice are planned to optimise weed control options and outcomes.

The canola year is pivotal in the weed control program for each paddock, particularly for:

- Managing annual ryegrass
- Managing herbicide (Group A) resistance annual ryegrass; and
- Reducing the risk of selecting weeds for herbicide resistance.

It starts with the choice of technology, either Roundup Ready ® or Triazine Tolerant, depending on the weed spectrum. During the season grass weeds are controlled with cheaper and more effective options than controlling them in cereals.

Murray says, "I still see a use for residual herbicides like Boxer Gold®, or trifluralin if we have to burn. We are getting good results when we use them in an Integrated Weed Management program."

At harvest the straw spreaders are removed from the header and all the residue is dropped in a windrow which is later burned. Murray has found this is a very effective way to reduce weed numbers, particularly annual ryegrass.

Implications of stubble retention on crop health and the soil

Although Murray doesn't feel he has strict science behind the benefits of stubble retention, he believes it is the natural state of play. He says, "Bare soil is just not natural". From what he has read he doesn't believe stubble retention is going to have a large short-term effect on soil carbon levels but in a holistic sense there is a benefit – water holding in the soil is the biggest one which in turn increases earthworm activity and microbe numbers.

Future opportunities and challenges

Short term changes to the cropping system will be limited. Murray and Barry have made significant changes during the past three years which are still being fine tuned. The next major step will be when the header is ready for replacement. The plan is to match up the header cut-width to the airseeder. Currently the airseeder and boomspray match but the header doesn't. Murray doesn't plan to go to a full controlled traffic system.

The biggest challenges Murray sees will be associated with a return to more normal seasons. Issues include getting through heavier stubble with the seeder, and crop diseases and pests, such as slugs and mice.

Murray sees there are two major threats to agriculture, climate and economics, with increased variability and volatility of both. Is this a dry spell we are experiencing and how long can it last? Is it a sign of increased variability in the seasons? How can we manage the huge variability and volatility of both commodity prices and input costs?

The Scholz family is committed to agriculture and on the whole remain positive. Murray sees a positive future, "Everybody has to eat!"

Case Study 11 (reprinted from 2008 report)

Terry Brown, Harden

Operation details: 2500 ha crop on properties at Harden, Milvale, and Wallendbeen; no livestock enterprise.

Soil type: loam to heavy clay and self mulching grey clay.

Farming system: no-till crop with no livestock grazing on paddocks while in crop phase of rotation. Pastures are legume only to enable grass weed control in the pasture phase.

Crop rotation: 6-year rotation of canola-wheat-canola-wheat-canola-wheat/legume pasture.

Tillage: no-till.

Stubble management: historically wheat stubble is burnt and canola stubble mulched with a disc chain. To reduce stubble burning it is intended to bale wheat stubble then disc chain as soon as moisture permits after harvest.

Background

Terry Brown's cropping operation is over a range of soil types and environments (rainfall and season length). He has been no-till farming since 1998, and the tillage practices have been adapted to best suit the conditions of each soil type as required. Retention of soil moisture and weed elimination are important factors in the management program. To assist with the logistics of managing a large area of crop he block farms (manages paddocks in groups) with units of approximately 200 ha.

The farming objective is to maximise returns by careful agronomic management and the adoption of the best farming techniques available, to minimise input costs without compromising returns.

Terry Brown's Flexicoil air seeder with tow-behind air cart and coil packer.

Cropping system

The cropping phase of the rotation is based around a Flexicoil airseeder (12 m wide, 23 cm row space) fitted with press wheels. When sowing pasture the press wheels are swapped with rotary harrows and combined with System 75 coil packers.

The original plant was purchased in 2002 with auto-steer added to the tractor in 2007 with the aim of minimising costs by eliminating overlap, and to reduce driver fatigue.

The sowing outfit has:

- Very accurate seed and fertiliser placement
- Good seed–soil contact to maximise germination, especially for canola
- The ability to move between press wheels and rotary harrows depending on soil type, available moisture and crop
- Good ground following capability
- The ability to sow with good results into a range of soil types, in any condition.

Some of the disadvantages of the outfit include:

- The tow behind air-cart generates some side movement on hilly country
- Inability to change row spacing because it is an alternate tine machine

- Machine height in transport can be an issue on the road and moving between paddocks
- The cultivator wheels require higher than expected maintenance–the wheel bearing and stub axles need regular checking and replacing. The wheels could be larger.

Stubble management

Up until 2007 Terry burnt stubble in late April/early May to prepare for cropping. However in 2008 he purchased a 13 m Kelly disc chain to mulch stubble and incorporate pre-emergent herbicide (trifluralin). The plan for 2009 is to remove the bulk of the straw by baling, and retain the balance of the crop residue to help retain soil moisture and maintain soil structure. Terry would like to eliminate stubble burning.

Weed management

Terry relies on application of herbicide to manage summer weeds in crop stubble, using high water rates (80 to 100 L/ha).

Oats baled for silage has been used very successfully to dramatically reduce the weed population in some *problem paddocks* over the past few years. The paddocks are sown to oats, cut and baled for silage, then treated with a knockdown herbicide immediately to control any regrowth.

Livestock management

Terry has no livestock of his own and only runs sheep on pasture paddocks under a share-farm arrangement.

Paddocks are not grazed during the cropping phase as Terry finds:

- Weeds can be better controlled with herbicides when there are no stock to compromise efficacy (e.g. timing, dust, target leaf area)
- Compaction by grazing livestock is avoided
- The large area of crop can be better managed if he is not spending time managing sheep.

Flexicoil tine and press wheels used for sowing crop.

Rotary harrows used in conjunction with coil packer to sow pasture.

Future opportunities and challenges

Terry believes that handling heavy stubble loads remains a major challenge. He may try baling stubble to improve residue flow through machinery at sowing. He is also interested in trying a disc chain or stubble mulching to aid sowing into heavy stubble loads.

'Our biggest challenge is to maintain crop yield and manage disease with heavy stubble loads and remain viable'.

Case Study 12 (reprinted from 2008 report)

Ken and Charlie Baldry, Wallendbeen

Property details: total 3500 ha; 1800 crop; 9000 ewes for prime lamb production.

Soil type: red basalt clay loam and granite sandy clay loam.

Farming system: mixed; no-till cropping; legume dominant perennial pasture to build up soil carbon and nitrogen.

Crop rotation: 6 to 7 years crop, predominantly wheat and canola; 4 years perennial pasture–lucerne, fescue and sub clover.

Tillage: no-till.

Stubble management practices: heavy grazing and late cool burn.

Background

Charlie Baldry and his family operate a mixed farming business with livestock and perennial pasture an important component.

Cropping system

In 1996, Baldry & Sons purchased an Ausplow DBS (Deep Blade System) seeder to move from reduced-till (one cultivation prior to sowing) to no-till. It features:

- High break-out hydraulic tines
- A parallelogram press wheel sowing system
- 26 cm row space
- An anhydrous ammonia application system.

Due to back filling problems caused by soil throw, harrows were fitted after two years. Initially Agmaster Star harrows were used but they did not leave the country level enough, particularly when the stars were worn. More recently they have been replaced with K-Line finger harrows.

Charlie Baldry with his Ausplow DBS seeder.

Weed management

Charlie uses an integrated weed management system which includes:

- Silage production during the pasture phase
- Attention to detail ensuring spring/ summer fallows prior to cropping are kept weed-free
- Rotation of herbicide groups
- Some strategic cultivation–usually when incorporating lime.

The four to five year pasture phase is based on perennial species with a strong legume component, and includes lucerne, fescue and sub clover. The pasture phase is used to increase the nitrogen and carbon levels of the soil.

Stubble management

Stubbles are heavily grazed immediately after harvest. Summer weeds are controlled with herbicides and grazing to conserve moisture. Stubbles are burnt during late April and early May to:

- Enable effective use of pre-sowing herbicide
- Control cereal leaf and crown diseases (wheat on wheat)
- Prevent seeder blockages
- Prevent canola establishment problems in heavy wheat stubbles.

Livestock management

Livestock are used in combination with herbicides to control summer weeds in stubble. The stubble also supplies some summer feed.

Future opportunities and challenges

Charlie feels the grains industry will face a challenge if soft commodity prices remain firm and the profitability of cropping justifies the risk of growing a larger proportion of crop or even continuously cropping. The system will need to be able to increase soil carbon levels, rather than mine carbon and degrade fertility. He is unsure if a system exists which can maintain or preferably increase soil carbon levels without a pasture phase, particularly in high rainfall areas.

Extending the cropping phase or continuous cropping also runs into serious issues with weed management, particularly herbicide resistant weeds such as annual ryegrass. GM technology may or may not solve that problem.

Measuring soil strength using a penetrometer at the Bobbara Station Field Day.

Field Day at Bobbara Station, 2007. Rob McColl said "If we are going to make annual cropping work in our dry climate, it will have to be with the kind of practice that conserves every drop of moisture we get, and has to be a no-till system with maximum ground cover".

Case Study 13 (reprinted from 2008 report)

Peter Cusack, Harden

Property details: 650 ha; 300 ha crop; 1600 sheep; contract sowing and spraying.

Soil type: loam and clay loam (better cropping); sandy loam (better suited to grazing).

Farming system: mixed; livestock an important component of the farm business; pastures are an important component of crop rotation, particularly on the lighter country.

Crop rotation: wheat–wheat–break crop–wheat undersown with pasture.

Tillage: no-till.

Stubble management: light grazing then sow with disc seeder.

Background

Peter Cusack and his family run a mixed farming operation at Harden based on a no-till system. He manages two distinct soil types–the better cropping country (loam and clay loam) and the lighter grazing areas (sandy loam). Livestock are a key component of the business. He currently runs 1600 merino ewes—1100 joined to terminal sires, 500 to merinos. Peter sold his cattle a few years ago due to the cost of feed and time taken to manage them.

Reduced-till farming was introduced in the early 1980s, and has helped reduce soil erosion and improve the soil's water holding ability.

Cropping system

The cropping program on the better soil type is usually two years wheat, then canola or lupins, one or two wheat crops, the final one undersown with lucerne which is maintained for three to five years.

The lighter country has more emphasis on pasture, with a maximum three years crop then back to four to five years pasture, based on cocksfoot, phalaris, fescue, sub clover and arrowleaf clover.

In 2006 a single disc seeder (John Deere 1590 Disc Drill) was purchased to replace a tined swing rig, with the aim of:

- Retaining stubble
- Maintaining ground cover
- Minimising soil disturbance during sowing
- Improving seed placement
- Maintaining soil-seed contact
- Improving fuel efficiency
- Sowing at a higher speed than a tine machine.

Peter said, 'Some exceptional crop establishment results were achieved in 2006. The pasture establishment and density were very impressive as well. I believe we achieved a yield advantage in cereals due to conservation of moisture.'

'Establishment and cleanliness of the early sown fodder crop was excellent due to the fact that we could sow one day after the opening rain and follow up with a knockdown spray before the crop came up, four to six days later.'

In 2008 this sowing unit was replaced with a larger machine, a 9 m Excel Stubble Warrior (23 cm row space). The Excel is very similar to the John Deere disc opener with a few improvements, such as a heavier bar which

Peter Cusack, son Will and the Excel Stubble Warrior disc seeder.

improves soil penetration in dry soil and the accessibility of parts locally.

The Excel Stubble Warrior consists of a 45 cm (18") single disc on a seven degree angle with a rubber depth gauge wheel, followed by a seed firming wheel, and then a slot closing wheel. The seed is placed in the shadow of the disc along with fertiliser in a single boot system. Each unit is set individually and seed placement is very accurate.

Peter has sown in excess of 5000 ha with the disc seeders over the past three years. Disc life was just under 4000 ha, similar to a knife point in the same country. He sees the advantages of a disc seeder over a tine machine include:

- Superior stubble handling capability
- Higher sowing speed
- Less soil disturbance and power requirement resulting in marked reduction in fuel consumption
- Easy seeding depth adjustment to match soil moisture.

Peter sees few limitations with the disc machine compared to a tined machine, but he has reported:

- There is no soil levelling ability so any ruts (e.g. sheep tracks) remain in the paddock from season to season, although the unit does neatly seed over them
- The disc units have to be greased daily
- Herbicides cannot be incorporated.

To conserve moisture summer weeds in stubble are controlled primarily with herbicide. Lucerne paddocks are winter-cleaned prior to coming back into crop. If pasture paddocks are particularly grassy Peter will sow a fodder rape crop for stock feed and to manage the grasses. When Peter makes hay or silage to conserve fodder he always chooses the weediest paddock, to help reduce the weed seedbank.

Stubble management

Ideally, Peter would prefer not to graze stubble paddocks and retain standing stubble cover. He lightly grazes all stubble paddocks;

Depth gauge wheel on the Excell Stubble Warrior disc seeder.

a balance between optimising ground cover and feeding sheep over summer. When feed is very short over summer he will sacrifice one stubble paddock and supplementary feed sheep there, rather than over-graze all paddocks.

A key to managing stubble is spreading residue evenly at harvest. This aides residue flow during sowing.

Livestock management

Sheep are grazed on pasture paddocks during the winter crop season and rotationally grazed on all paddocks during summer. Supplementary feeding (grain, hay or silage) is only used in drought situations.

Future opportunities and challenges

Peter sees the inability to effectively incorporate pre-sowing residual herbicides as a challenge in his full stubble retention, direct-drill system. He sees Roundup Ready® canola and the application of a non-selective herbicide as an additional weed management tactic to add to the system. The use of a disc chain for light cultivation to incorporate herbicide may also be an option.

Although Peter does not cultivate or burn stubble, he would consider using these tactics to help in an integrated weed management program.

Case Study 14 (reprinted from 2008 report)

Peter Holding, Harden

Property details: 600 ha; 400 ha crop; 200 ha improved pasture; 2100 sheep.

Soil type: sandy clay loam.

Farming system: mixed, pasture phase important; livestock used to reduce stubble load and manage weeds over summer.

Crop rotation: continuous winter cropping (canola-wheat-lupin or faba bean-wheat-canola undersown); approximately six years crop, then four or five years pasture.

Tillage: direct-drill.

Stubble management: mulched with Coolamon harrows immediately after harvest then grazed at high stocking rates on a rotational basis.

Background

Peter Holding has been heavily involved with Landcare activities since 1989 and with his family, operates a mixed farm east of Harden. Direct-drill annual cropping and sheep are the key components of the whole farm system.

Cropping system

For over 20 years, the cropping program has been a direct-drill system based on wheat and canola with some pulse crops. During the past five years Peter has not sown a pulse crop due to the drought, late seasonal breaks, poor yield and uncertain price. He plans to reintroduce lupins or faba beans into the crop cycle. The aim is to start the crop phase after a good weed-free pasture. The past few seasons have made this a challenge and more recently some weedy paddocks have been put back into crop to *tidy them up*.

After the 1982 drought through to 1985 Peter experimented with reduced-till and no-till cropping because soil erosion was a large problem on the sloping country with heavy summer storms. Wind erosion was also an issue after the ´82 drought and with declining soil structure. Peter had just completed an agricultural degree at Charles Sturt University and he had become interested in research into direct-drilling being done at the Wagga Wagga Agricultural Research Institute. Peter decided to see if he could make it work.

The implementation of direct-drill has helped reduce soil erosion and improve soil characteristics such as:

- Water holding capacity
- Organic carbon levels
- Soil structure.

It is a continually evolving process–always developing–requiring further research. Changes to the system require a few years to show the true benefits, and as the system changes, so do the issues faced. There are many options and directions to take e.g. controlled traffic farming and inter-row sowing; baling stubble and developing uses and markets for the straw; to graze or not to graze. The system needs to be adaptable and

Peter Holding with his modified John Shearer Trash Culti Drill.

will vary from farm to farm, year to year and paddock to paddock.

Peter modified his John Shearer Trash Culti Drill (19 rows, 20 cm row space). The key changes he made were:

- Removing cultivating tines
- Raising the seed and fertiliser boxes to improve stubble flow
- Replacing the tines with stronger coil tines
- Adding press wheels to replace the Flexicoil roller used to improve seed-soil contact and germination.

The Shearer combine was easily and cheaply converted to a direct-drill planting unit with good stubble handling capability.

In addition, an anhydrous ammonia gas applicator was added and small seed box mounted on the frame.

The disadvantages of the machine are the width limitation and the relatively slow sowing speed required to achieve good seed and fertiliser placement (as the machine doesn't have good the ground following ability of some other seeding units). It is also difficult to prevent soil throw, even at slow speeds.

Stubble management

Grazing, in conjunction with the use of the Coolamon harrows (as soon as practical after harvest), is the preferred method of managing stubble to enable subsequent crops to be sown. Cereal stubble paddocks are ranked according to their position in the rotation and following crop, and are grazed accordingly. For example, stubble paddocks to be sown with early grazing wheat are kept clean by grazing and herbicide application, as opposed to those to be late sown, which may be left with slightly more green growth. Canola stubble is much less of a problem and crops are easily sown in these paddocks.

Peter is interested in exploring other options of stubble management practices such as baling straw. 'This may fit with livestock grazing on winter cereals by providing the required roughage'. Peter has plans to only have breeding sheep on paddocks, growing out prime lambs in a feedlot, utilising the baled straw, another piece in the stubble management puzzle.

Weed management

Peter has a keen focus on managing weeds and reducing the weed seed-bank The main winter weeds include wild radish and annual ryegrass, and occasionally black oats and skeleton weed. A combination of herbicides and grazing is used to manage these weeds. Peter attributes the success of his weed management program to the:

- Crop rotation with the inclusion of a pasture phase
- Use of strategic grazing
- Well planned use of herbicides
- Use of detailed and appropriate consultancy advice, keeping up to date with herbicides and weed management research.

Weed control over summer in stubble is critical to successfully sowing through stubble.

Livestock management

The sheep are heavily integrated into the cropping with the use of grazing wheat (and potentially grazing canola). The sheep are only on the pasture area from crop lockup in mid-spring through to harvest, and again in late autumn. Sheep are grazed on crop stubble from harvest until these paddocks are sown. Supplementary feeding includes silage cut from the pasture paddocks, minerals, and lick feeders with grain when required.

Future opportunities and challenges

Soil throw is a problem but doesn't appear to be critical. Peter is going to try a slightly different tine pattern which may give a better result. The challenge is optimising stubble flow while minimising uneven soil throw and sideways movement by the sowing plant. Part of the problem is caused by the build up of soil around the tines caused by the anhydrous ammonia applicator in close proximity to the sowing tine. This may be solved by better insulation or changing the fertilizer delivery.

Case Study 15 (reprinted from 2008 report)

Bobbara Station, Galong

Property details: 4500 ha; 1700 ha crop; 500 Angus/Wagu cows; 7000 ewes joined to X-bred composite rams; and opportunity cattle trading.

Soil type: sandy clay loam.

Farming system: mixed no-till cropping and livestock.

Crop rotation: canola-wheat-canola-wheat-wheat rotation with the last crop under-sown to a lucerne or grass based pasture.

Tillage: direct-drill system since the early 1990s. No-till since purchase of Conserva Pak in 1998.

Stubble management practices: traditionally have burned cereal stubble but sown into canola stubble. Recently have started using a rotary disc chain combined with heavy grazing to reduce stubble load. Occasionally bale straw.

Background

Bobbara Pastoral Company has been direct-drilling since the early 1990s. Cropping has played an important part of the farm business, both as a financial contributor and in the control of weeds, such as scotch thistle. Paddocks generally have a five year crop phase followed by a five to six year grass- or legume-based pasture phase, with the aim of maximising returns.

Cropping system

Rob McColl, has been the Cropping Manager at Bobbara Station since 2002. He said, '2002 was a real eye opener and never was it more evident that we needed to conserve as much moisture as possible. We received only 418 mm [of rain] that year including one rain event in February that delivered 156 mm. Our in-crop rain was half that of a normal year. Since then we have kept stubbles as clean as possible and cover on paddocks for as long as possible, to both capture and retain that water.

Rob McColl with his Conserva Pak cultivator.

The soils look better since the move to no-till. There is more visible organic matter in the soil and plenty of worms.'

Rob sows with a ConservaPak cultivator (12 m, 30 cm row space) and a Flexicoil airseeder. Narrow press wheels have been replaced with 100 mm wide, pneumatic press wheels for improved seed soil contact. The 30 cm row spacing (compared to the 22 cm previously used) has improved residue flow through the machine and helps reduce soil throw onto other rows.

The ConservaPak gives:

- Excellent seed and fertiliser placement at the required depth because each of the seed and fertiliser placement units follows the ground level individually
- Good seed-soil contact, with the pressure of the press wheel easily adjusted for different conditions
- Good stubble handling capability
- Very little soil disturbance because of the use of narrow points.

It is a very reliable system that can be used in a variety of soil types, soil conditions and cropping systems.

Stubble and weed management

Rob uses a Brookfield disc chain to:

- Manage stubble
- Provide a light cultivation prior to under-sowing pasture
- Incorporating pre-emergent residual herbicides, such as trifluralin.

Rob finds that the disc chain complements minimum tillage well in that when a light cultivation is required it fills the gap. The disc chain is brilliant for incorporating trifluralin before sowing.

The disc chain was used on wheat stubbles in 2007 and did a great job preparing them for sowing. The shallow cultivation (2-3 cm) encouraged a germination of weeds which were cleaned up with a fallow knockdown spray.

Stubble will be grazed heavily (up to 50 DSE) if it is too heavy to sow through. On occasion, if necessary, stubble will be burnt to control crop disease and weeds.

Future opportunities and challenges

There is a concern that the 30 cm row space will limit yield in high yielding seasons (wheat over 4 t/ha). It is felt that the large increase in seed number per meter of row is likely to reduce tillering ability in wheat. As a solution to this, Rob is looking at using a paired-row sowing system. The tine spacing would remain the same (30 cm) but each sowing tube would be split, delivering seed to two rows 7.5 cm apart.

Rob is also concerned that if the 30 cm row space results in reduced tiller number per hectare the dry-matter production of the grazing cereals will be reduced. However he can usually sow into moisture that has been conserved by retained stubble that a narrower tined machine may not get through. This allows him to establish grazing

A disc chain can be used to mulch stubbles to increase the speed of breakdown and improve residue flow through seeding equipment.

cereals earlier, which may well be sufficient compensation for the effects of wider row spacing.

Controlled traffic farming and inter-row sowing are not practical options for Bobbara Station due to the slope of most country. Erosion of the wheel tracks is likely and the sowing plant would have to be scaled back to get enough horsepower to the ground (perhaps with a track tractor). Inter-row sowing is also challenging on sloping country where the cultivator drifts sideways and is hard to keep between the rows.

Rob can see benefits of a disc machine for sowing but he believes he would have to go 'no stock' to remove summer compaction to avoid sowing problems. He is not convinced that the disc machine would work on hard compacted paddocks such as previous grazing-cereal paddocks.