Active stubble management to enhance residue breakdown and subsequent crop management — focus farm trials

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Background

This report presents the results from the large plot focus farm trials of the *Maintaining profitable farming systems with retained stubble in the Riverine Plains region* project, as described in the introductory report on page 4.

Method

Different methods of stubble management were trialled in four large (farm-scale) replicated trials during 2014. All results were statistically analysed using analysis of variance (ANOVA), with means separated using the unrestricted least significant difference (LSD) procedure. The different trial treatments are outlined in Table 1.

TABLE 1 Stubble management project trial details

Trial details	Trial 1 Daysdale	Trial 2 Yarrawonga	Trial 3 Dookie	Trial 4 Henty
Treatments				
NTSR* (control)	✓	✓	✓	✓
NTSR^ + 40kg extra nitrogen at sowing	✓	✓	✗	✓
Cultivate	Two passes	One pass	Two passes	One pass
Cultivate + 40kg N/ha at sowing	Two passes	One pass	✗	One pass
Burn stubble	✓	✓	✓	✗
NTSR – long stubble	✗	✗	45cm	✗
NTSR — straw mown and removed	✗	✓	✓	✗
NTSR — stubble mulched and retained	✗	✗	✗	✓
NTSR — stubble mulched + 40kg extra nitrogen at sowing	✗	✗	✗	✓
NTSR — faba beans sown for forage	✓	✗	✗	✗
NTSR — faba beans sown for grain	✓	✗	✗	✗
Trial plot dimensions	40 x 15m	40 x 18m	40 x 12m	40 x 15m
Farm drill used for trial	Aus seeder DBS D-300 tine seeder	Aus seeder DBS tine knife point	Simplicity seeder/ knife point	John Deere 1590 disc seeder
Stubble loading (t/ha)	6.4	8.3	7.4	7.8
Stubble height (cm)	33	40	15	47
Soil type description	Heavy grey clay	Self-mulching red loam over grey clay	Red clay	Yellow podzol–yellow-brown earth
Row spacing (cm)	30	38	33.3	19
Crop and rotation position	Second wheat	Second wheat	Second wheat	Canola after wheat

* NTSR — no-till full stubble retention
^ 40kg extra nitrogen at sowing – an additional 40kg N/ha broadcast before cultivation or sowing date.
All cultivation was carried out with a Lely multidisc cultivator except Henty, where a K-Line Speedtiller cultivator was used.



Trial 1: Daysdale, NSW

Key points

- There was no economic return from burning, cultivating or adding additional nitrogen (N) at sowing when establishing wheat on wheat on a heavy grey clay.
- Burning first wheat stubble and adding additional nitrogen at sowing significantly reduced the severity of yellow leaf spot (YLS) *Pyrenophora tritici repentis* during tillering and was evident at grain fill, though disease levels were low (5% on Flag-1).
- The average wheat yield from all treatments was 3.19t/ha from a total harvest dry matter (DM) of 8.41t/ha.
- In the same trial, faba bean plots yielded 2.89t/ha as grain and 6.68t/ha was harvested as forage DM at the late pod-fill stage.

Sowing date: 24 April 2014
Rotation: Second wheat
Variety: Wheat cv Whistler, faba beans cv Fiesta
Stubble: Wheat (various treatments applied)
Rainfall:
GSR: 332.6mm (April–October)
Summer rainfall: 70.2mm
Soil nitrogen at sowing: 93kg N/ha in NTSR (control) and 56kg N/ha in multidisc (0–60cm)

Results

i) Establishment and crop structure

Top working (cultivating) the heavy clay soil at low soil moisture levels resulted in a cloddy seedbed with significantly lower plant establishment (plants/m^2) and poorer vigour compared with the burn and no-till full stubble retention (NTSR) control blocks. However there were no statistical differences at the end of tillering/start of stem elongation (GS31) or when head numbers were assessed at harvest (Table 2).

ii) Weed population

Initial differences in annual ryegrass (*Lolium rigidum*) populations following pre-emergence treatment of herbicides revealed a trend for faba beans to carry a higher level of ryegrass, however at harvest there was no difference (Table 3).

TABLE 3 Broadleaf and ryegrass weed populations 21 May 2014, crop three leaves unfolded (GS13) and ryegrass 19 November 2014, harvest (GS99)

	Weeds (m^2)		
	GS13		GS99
Treatment	Broadleaf	Ryegrass	Ryegrass
NTSR (control)	0^{a}	3^{ab}	6^{a}
Burn	1^{a}	1^{b}	9^{a}
Cultivate (two passes)	1^{a}	0^{b}	10^{a}
Cultivate (two passes) + 40kg N/ha	0^{a}	1^{b}	2^{a}
Faba beans as grain	1^{a}	12^{ab}	6^{a}
Faba beans as forage	0^{a}	16^{a}	3^{a}
Mean	0.37	5.37	6.00
LSD	1.69	13.29	8.59

Figures followed by different letters are regarded as statistically significant.

TABLE 2 Plant counts and vigour 15 May 2014, one-leaf stage (GS11); plant counts 21 May 2014, three leaves unfolded (GS13); tiller counts 6 August 2014, first node (GS31) and head counts 19 November 2014, harvest (GS99)

	Crop growth stage				
	GS11		GS13	GS31	GS99
Treatment	Plants/m^2	Vigour*	Plants/m^2	Tillers/m^2	Heads/m^2
NTSR (control)	109^{a}	8^{b}	121^{a}	330^{a}	317^{ab}
Burn	112^{a}	9^{a}	117^{a}	356^{a}	335^{a}
Cultivate (two passes)	86^{ab}	6^{c}	94^{b}	382^{a}	337^{a}
Cultivate (two passes) + 40kg N/ha	77^{b}	6^{c}	84^{b}	367^{a}	282^{b}
Mean	**96**	**7.31**	**104**	**359**	**317**
LSD	28	0.55	23	75	43

* Vigour — measured on a scale of 1–10 where 1 = poor vigour
Figures followed by different letters are regarded as statistically significant.

iii) Dry matter production and nitrogen uptake

There were no differences in DM production or nitrogen uptake due to the stubble treatments applied. The mean DM and nitrogen uptake in the wheat at harvest was 8.41t/ha and 79kg N/ha, respectively.

iv) Disease levels

Burning and the addition of 40kg N/ha at sowing significantly decreased yellow leaf spot (YLS) (*Pyrenophora tritici repentis*) infection relative to the NTSR control when assessed at tillering during June (Table 4). Although disease levels were very low (5% severity on flag-1) the effects of stubble management and nitrogen application were still evident at grain fill (Table 5).

TABLE 4 Yellow leaf spot severity and incidence of the two newest fully-emerged leaves (flag-7, flag-8), assessed 19 June 2014 main stem and two tillers (GS22)

	YLS at GS22			
	Severity (% leaf area infected)		Incidence (% leaves infected)	
Treatment	Flag-7	Flag-8	Flag-7	Flag-8
NTSR (control)	0.4[a]	3.1[ab]	32.5[a]	95.0[a]
Burn	0.1[b]	0.1[c]	5.0[b]	47.5[b]
Cultivate (two passes)	0.3[a]	3.5[a]	30.0[a]	97.5[a]
Cultivate (two passes) + 40kg N/ha	0.2[ab]	1.5[bc]	15.0[ab]	87.5[a]
Mean	**0.23**	**2.14**	**20.6**	**81.9**
LSD	0.25	1.94	21.7	20.4

Figures followed by different letters are regarded as statistically significant.

v) Yield and grain quality

The different treatments produced no significant differences in either wheat yield or quality (Table 6). The faba beans harvested as forage on 31 October 2014 yielded an average of 6.68t/ha and when taken through to grain yielded 2.89t/ha.

Commercial application

For the establishment of second wheat on heavy grey clay with a yield potential of just over 3t/ha there was no yield gain from actively managing stubble from the previous wheat crop.

In year one of this experiment there was no economic return from either burning, cultivating or adding additional nitrogen before crop establishment.

There was evidence that adding more nitrogen at sowing, and burning, significantly reduced the severity of YLS, factors that could have more relevance in a wetter spring with higher disease pressure.

TABLE 5 Yellow leaf spot severity, incidence and green leaf retention (GLR) assessed 15 October 2014 mid–late flowering (GS68–70) on flag and flag-1

	YLS at GS68–70					
	Severity (% leaf area infected)		Incidence (% leaves infected)		GLR (% of leaf green)	
Treatment	Flag	Flag-1	Flag	Flag-1	Flag	Flag-1
NTSR (control)	0.68[ab]	5.4[a]	30.0[a]	67.5[a]	90.7[a]	53.1[a]
Burn	0.35[b]	1.5[b]	25.0[a]	55.0[a]	91.2[a]	57.8[a]
Cultivate (two passes)	1.00[a]	3.0[ab]	35.0[a]	65.0[a]	92.6[a]	49.1[a]
Cultivate (two passes) + 40kg N/ha	0.50[ab]	1.7[b]	37.5[a]	65.0[a]	91.1[a]	53.0[a]
Mean	**0.63**	**2.9**	**31.9**	**63.1**	**91.4**	**53.2**
LSD	0.65	3.0	20.7	21.4	4.0	16.0

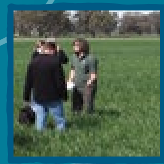
Figures followed by different letters are regarded as statistically significant.

TABLE 6 Wheat yield, test weight, protein and screenings 27 November 2014, at harvest (GS99)

Treatment	Yield (t/ha)	Test weight (kg/hL)	Protein (%)	Screenings (%)
NTSR (control)	3.17[a]	78.9[a]	8.1[a]	4.5[a]
Burn	3.10[a]	78.5[a]	8.1[a]	4.6[a]
Cultivate (two passes)	3.18[a]	79.1[a]	8.8[a]	4.2[a]
Cultivate (two passes) + 40kg N/ha	3.31[a]	78.3[a]	8.4[a]	5.0[a]
Mean	**3.19**	**78.7**	**8.4**	**4.56**
LSD	0.53	1.52	1.22	1.42

Figures followed by different letters are regarded as statistically significant.





Trial 2: Yarrawonga, Victoria

Key points

- Later-sown second wheat (20 May cv Young) established using no-till full stubble retention (NTSR) showed less dry matter (DM) production and nitrogen (N) uptake during stem elongation compared with crops where stubble was burnt, cultivated or removed.
- Although there were no statistical differences in yield, NTSR crops were the lowest yielding in a trial where yields ranged from 4.18–4.54t/ha.
- Burning significantly reduced yellow leaf spot (YLS) infection and decreased volunteer wheat populations before sowing compared with NTSR and cultivation treatments.
- NTSR crops had significantly lower test weights and higher screenings than crops established after stubble removal, burning or cultivation.

Sowing date: 20 May 2014
Rotation: Second wheat
Variety: Young
Stubble: Wheat (various treatments applied)
Rainfall:
GSR: 373mm (April–October)
Summer rainfall: 114mm
Soil nitrogen: 60kg N/ha NTSR (control), 51kg N/ha mulitdisc 0–60cm (8 May, before 35mm of rain during late April, early May)

Results

i) Establishment and crop structure

Establishment was lowest in the NTSR (control) blocks (131 plants/m^2), however there was no statistical difference between this and the other stubble treatments (Table 7). Visual vigour assessments indicated faster emergence and more uniform stands where straw was baled and removed, cultivated or burnt compared with the NTSR. Tillering was significantly lower in the NTSR control, however applying an extra 40kg N/ha at sowing increased tiller numbers to the levels observed in the burn or cultivated plots. By harvest, the number of heads in the NTSR control was comparable to the other stubble treatments.

ii) Weed populations

Weed populations in the trial were low. There were differences recorded in the growth of volunteer wheat before sowing, with burning giving the lowest volunteer population (Table 8). Assessments post emergence and at harvest showed weed populations to be very low and with no differences observed.

iii) Dry matter production

The NTSR control treatment produced significantly lower DM throughout the season than the other treatments. At harvest the differences were not significant except where extra nitrogen was added at sowing to the cultivated plots, however the lowest harvest DM results were associated with NTSR (Table 9).

TABLE 7 Plant counts and canopy vigour scores 6 June 2014, one-leaf stage (GS11); plant counts 17 June 2014 three leaves unfolded (GS13); tiller counts 28 August 2014, second node (GS32) and head counts 25 November 2014, harvest (GS99)

	Crop growth stage				
	GS11		GS13	GS32	GS99
Treatment	Plants/m^2	Vigour*	Plants/m^2	Tillers/m^2	Heads/m^2
NTSR (control)	131^{a}	5.3^{b}	174^{a}	240^{b}	311^{ab}
NTSR + 40kg N/ha	164^{a}	6.0^{ab}	191^{a}	303^{a}	355^{a}
Burn	170^{a}	7.3^{a}	195^{a}	301^{a}	300^{b}
Control + 40kg N/ha	164^{a}	6.0^{ab}	191^{a}	303^{a}	355^{a}
Remove straw	172^{a}	7.3^{a}	195^{a}	287^{a}	293^{b}
Cultivate (one pass)	150^{a}	6.8^{a}	175^{a}	304^{a}	326^{ab}
Cultivate (one pass) + 40kg N/ha	156^{a}	6.5^{ab}	172^{a}	325^{a}	320^{ab}
Mean	**157**	**6.5**	**184**	**294**	**317**
LSD	49	1.4	41	40	54

* Vigour — measured on a scale of 1–10 where 1 = poor vigour
Figures followed by different letters are regarded as statistically significant.

TABLE 8 Pre-sowing volunteer wheat 2 May 2014

Treatment	Weeds (m^2)
	Pre-sowing volunteers
NTSR (control)	7^{b}
NTSR + 40kg N/ha	15^{ab}
Burn	2^{b}
Remove straw	24^{ab}
Cultivate (one pass)	37^{a}
Cultivate (one pass) + 40kg N/ha	21^{ab}
Mean	**18**
LSD	28

Figures followed by different letters are regarded as statistically significant.

iv) Nitrogen uptake

Nitrogen uptake by the crop canopy by flowering was significantly lower in the NTSR and straw-removed no-till treatments (Table 10) compared with burning and cultivation, however greatest nitrogen uptake was measured where additional nitrogen was applied at sowing.

v) Yellow leaf spot control

When assessed at the start of stem elongation (GS30), burning had resulted in approximately 85% reduction of YLS compared with NTSR (control) on flag-7 (Table 11). Removing straw by raking reduced YLS in the crop. Cultivation was observed to have little or no effect.

At this site the differences in YLS infection after the booting stage were not assessed as disease levels were low all season.

Additionally, within each replicate plot, an area was set up to exclude a grower-applied application of fungicide (Folicur 150ml/ha applied on 12 August 2014 GS31) by placing a plastic sheet over a defined area during spraying. When these areas were assessed at GS32 and GS51 the applied fungicide was assessed to have had little or no effect on YLS severity and incidence relative to the untreated, area of the crop.

TABLE 9 Dry matter 28 August 2014, second node (GS32); 23 September 2014, mid-booting to start of ear emergence (GS45–51); 15 October 2014, mid-late flowering (GS65–69) and 25 November 2014, harvest (GS99)

Treatment	Dry matter (t/ha)			
	GS32	GS45–51	GS65–69	GS99
NTSR (control)	1.5^{b}	3.9^{b}	6.7^{c}	7.8^{b}
NTSR + 40kg N/ha	2.1^{a}	4.8^{a}	7.9^{ab}	8.5^{ab}
Burn	2.5^{a}	5.0^{a}	8.4^{a}	8.2^{ab}
Remove straw	2.4^{a}	4.9^{a}	7.3^{bc}	8.4^{ab}
Cultivate (one pass)	2.1^{a}	4.7^{a}	7.4^{bc}	7.8^{b}
Cultivate (one pass) + 40kg N/ha	2.3^{a}	5.1^{a}	7.8^{ab}	9.2^{a}
Mean	**2.1**	**4.8**	**7.6**	**8.3**
LSD	0.5	0.7	0.8	1.2

Figures followed by different letters are regarded as statistically significant.

TABLE 10 Nitrogen uptake in biomass 28 August 2014 second node (GS32); 23 September 2014, mid-booting to start of ear emergence (GS45–51); 15 October 2014, mid-flowering (GS65–69) and 25 November 2014, harvest (GS99)

Treatment	Nitrogen uptake in biomass (kg N/ha)			
	GS32	GS45-51	GS65–69	GS99
NTSR (control)	43^{b}	60^{b}	75^{c}	78^{bc}
NTSR + 40kg N/ha	46^{ab}	99^{a}	112^{a}	94^{b}
Burn	54^{ab}	73^{b}	96^{b}	83^{bc}
Remove straw	48^{ab}	65^{b}	72^{c}	58^{d}
Cultivate (one pass)	58^{a}	70^{b}	93^{b}	74^{cd}
Cultivate (one pass) + 40kg N/ha	58^{a}	107^{a}	104^{a}	131^{a}
Mean	**51**	**79**	**93**	**86**
LSD	13	15	14	16

Figures followed by different letters are regarded as statistically significant.



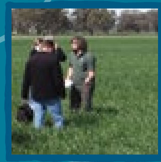


TABLE 11 Yellow leaf spot severity and incidence of the two newest fully-emerged leaves (flag-6, flag-7), assessed 22 July 2014, stem elongation (GS30)

Treatment	YLS (%) at GS30			
	Severity (% leaf area infected)		Incidence (% of leaves infected)	
	Flag-6	Flag-7	Flag-6	Flag-7
NTSR (control)	2.6^{a}	9.6^{a}	92.5^{a}	100.0^{a}
NTSR + 40kg N/ha	2.5^{ab}	7.9^{ab}	100.0^{a}	100.0^{a}
Burn	0.5^{c}	1.3^{c}	37.5^{b}	70.0^{b}
Remove straw	2.0^{b}	6.0^{b}	90.0^{a}	100.0^{a}
Cultivate (one pass)	2.6^{a}	9.4^{a}	92.5^{a}	100.0^{a}
Cultivate (one pass) + 40kg N/ha	2.5^{ab}	9.2^{a}	90.0^{a}	100.0^{a}
Mean	**2.1**	**7.2**	**83.8**	**95.0**
LSD	0.6	2.4	13.4	8.4

Figures followed by different letters are regarded as statistically significant.

vi) Yield and grain quality

Yields ranged from 4.18–4.54t/ha with no significant differences between treatments.

There were significant effects of treatment on grain quality with the lower-yielding NTSR treatments giving lower test weight and higher screenings than where stubble was cultivated, burnt or removed. Applying nitrogen at sowing significantly increased protein levels in the NTSR control treatment (Table 12).

Commercial application

In year one of this trial there was no significant evidence of a yield decrease from using NTSR in this later-sown second wheat rotation position. However, many other recorded characteristics (DM accumulation, nitrogen uptake, test weight and screenings) were less in the NTSR crops compared with crops grown using active stubble management such as burning, straw removal and cultivation. While active stubble management treatments have their own issues (reduced organic matter and nutrient return to the soil) the results suggest that later-sown (May) NTSR scenarios may be more responsive to active management than earlier-sown crops (April) where seedbeds are warmer, particularly if seedbeds are also wetter than normal for the time of year.

TABLE 12 Yield, protein, screenings and test weight 27 November 2014, harvest (GS99)

Treatment	Yield and quality			
	Yield (t/ha)	Test weight (kg/hL)	Protein (%)	Screenings (%)
NTSR (control)	4.18^{a}	79.2^{c}	10.5^{bc}	5.4^{b}
NTSR + 40kg N/ha	4.18^{a}	78.2^{c}	12.0^{a}	10.0^{a}
Burn	4.43^{a}	82.1^{a}	9.9^{bc}	2.6^{d}
Remove straw	4.53^{a}	81.4^{ab}	9.6^{c}	2.9^{d}
Cultivate (one pass)	4.54^{a}	81.3^{ab}	9.9^{bc}	3.4^{cd}
Cultivate (one pass) + 40kg N/ha	4.30^{a}	80.9^{b}	11.1^{ab}	5.3^{bc}
Mean	**4.36**	**80.5**	**10.5**	**4.9**
LSD	0.46	1.0	1.2	1.9

Figures followed by different letters are regarded as statistically significant.

Trial 3: Dookie, Victoria

Key points

- Different active stubble management treatments produced second-wheat yields ranging from 4.98–5.85t/ha cv Corack.
- Stubble length of the previous crop had a significant effect on yield when adopting no-till stubble retention (NTSR). Long stubble (approximately 45cm) significantly decreased yield by 0.7t/ha in second-wheat crops compared with those established in short stubble (15cm).
- This yield reduction was associated with significantly lower dry matter (DM) production and nitrogen (N) uptake in the stem elongation phase of crop growth.
- NTSR crops grown on short stubble also showed significantly lower DM production compared with crops following burning, straw removal and cultivation (two passes), but the reduction was less pronounced and did not reduce yield.

Sowing date: 16 May 2014
Rotation: Second wheat
Variety: Corack
Stubble: Wheat (various treatments applied)
Rainfall:
GSR: 386mm (April–October)
Summer rainfall: 78mm
Soil nitrogen: 75kg N/ha NTSR (control), 88kg N/ha multidisc in 0–60cm (2 May 2014)

Results

i) Establishment and crop structure

The crop structure assessments revealed small but significant differences in plant establishment, vigour and tiller number (Table 13). Crops established in long stubble (approximately 45cm) had significantly lower plant establishment at the three-leaves-unfolded stage (GS13) than crops where stubble was burnt or raked and removed. Long stubble also reduced tillering relative to other establishment treatments. At maturity there was a degree of compensation in the crops established in long stubble, as there were no significant differences in head number.

ii) Weed populations

The various establishment treatments produced significant differences in the volunteer wheat population recorded at sowing, with two cultivation passes (top working) giving rise to four times the number of wheat volunteers compared with the no-till treatments (Table 14). Burning resulted in no wheat volunteers at assessment.

TABLE 14 Pre-sowing volunteer wheat 2 May 2014 and grass weeds 17 June 2014 three leaves unfolded (GS13)

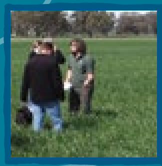
	GS00	GS13
Treatment	Volunteer wheat (plants/m²)	Weeds (plants/m²)
Short stubble (NTSR control)	12^{b}	0^{b}
Long stubble (NTSR)	8^{b}	2^{a}
Burn	0^{b}	1^{ab}
Remove straw	16^{b}	0^{b}
Cultivate (two passes)	52^{a}	1^{ab}
Mean	**18**	**0.67**
LSD	17	1.36

Figures followed by different letters are regarded as statistically significant.

TABLE 13 Plant counts and canopy vigour 30 May 2014, one-leaf stage (GS11); plant counts 17 June 2014, three leaves unfolded (GS13); tiller counts 28 August 2014, first node (GS31) and head counts 25 November 2014, harvest (GS99)

	Crop growth stage				
	GS11		GS13	GS31	GS99
Treatment	Plants/m²	Vigour*	Plants/m²	Tillers/m²	Heads/m²
Short stubble (NTSR control)	133^{a}	7.50^{cd}	136^{ab}	306^{a}	294^{a}
Long stubble (NTSR)	127^{a}	7.00^{d}	127^{b}	233^{b}	285^{a}
Burn	138^{a}	8.75^{a}	142^{a}	350^{a}	303^{a}
Remove straw	138^{a}	8.00^{bc}	142^{a}	306^{a}	301^{a}
Cultivate (two passes)	123^{a}	8.25^{ab}	134^{ab}	312^{a}	295^{a}
Mean	**132**	**7.90**	**136**	**301**	**296**
LSD	17	0.61	14	51	42

*Vigour — measured on a scale of 1–10 where 1 = poor vigour
Figures followed by different letters are regarded as statistically significant.



iii) Dry matter production

The main differences in crop DM production were associated with long stubble, with these crops producing significantly less DM than all other active stubble treatments when assessed from first node (GS31) to flowering (GS65) (Table 15).

For the same period of growth, crops established in burnt stubbles and after two cultivation passes produced the greatest amount of DM.

iv) Nitrogen uptake

In the stem elongation phase of crop growth the nitrogen uptake was significantly lower in the long-stubble treatment than all other treatments, including the NTSR control (short stubble) (Table 16). The greatest nitrogen uptake into the canopy by this growth stage was measured in the burnt treatment.

Disease levels were extremely low at this trial site with less than 1% disease severity and 25% disease incidence on leaves during early tillering. Even with these extremely low levels of yellow leaf spot (YLS) (*Pyrenophora tritici repentis*), burning stubbles resulted in crops with the lowest levels of infection (data not shown).

v) Yield and grain quality

Yields ranged from 4.98–5.85t/ha. Although second wheat crops grown after burning produced the highest yields (0.2–0.3 t/ha better than the next best treatments), the only difference in yield was measured with the crop grown in longer stubble, which yielded significantly less than all other establishment techniques (Table 17). The lower yield in this treatment also correlated with higher protein levels than those measured following burning or cultivating.

Commercial application

When reviewing the results from this trial work it is important to note they are the collation of only one year of data.

The most important application of this work arises from the influence of stubble length on DM production, tillering and final yield.

TABLE 15 Dry matter 14 August 2014, first node (GS31); 17 September 2014, start of ear emergence (GS51); 3 October 2014, mid-flowering (GS65) and 21 November 2014, harvest (GS99)

Treatment	Dry matter (t/ha)			
	GS31	GS51	GS65	GS99
Short stubble (NTSR control)	1.80^{b}	5.14^{c}	7.78^{b}	10.10^{ab}
Long stubble (NTSR)	1.34^{c}	4.02^{d}	6.85^{c}	9.86^{b}
Burn	2.11^{a}	5.94^{a}	9.12^{a}	11.18^{a}
Remove straw	2.01^{ab}	5.43^{bc}	8.39^{ab}	10.72^{ab}
Cultivate (two passes)	1.98^{ab}	5.65^{ab}	8.71^{a}	10.72^{ab}
Mean	**1.85**	**5.24**	**8.17**	**10.52**
LSD	0.23	0.49	0.86	1.18

Figures followed by different letters are regarded as statistically significant.

TABLE 16 Nitrogen uptake in biomass 14 August 2014, first node (GS31); 17 September 2014, start of ear emergence (GS51); 3 October 2014, mid-flowering (GS65) and 21 November 2014, harvest (GS99)

Treatment	Nitrogen uptake (kg N/ha)			
	GS31	GS51	GS65	GS99
Short stubble (NTSR control)	62^{b}	94^{ab}	97^{b}	114^{a}
Long stubble (NTSR)	45^{c}	82^{b}	112^{ab}	118^{a}
Burn	78^{a}	114^{a}	119^{ab}	125^{a}
Remove straw	67^{ab}	95^{ab}	125^{a}	111^{a}
Cultivate (two passes)	66^{ab}	100^{ab}	103^{ab}	125^{a}
Mean	**64**	**97**	**111**	**119**
LSD	12	26	23	24

Figures followed by different letters are regarded as statistically significant.

TABLE 17 Yield, protein, screenings and test weight 21 November 2014, harvest (GS99)

Treatment	Yield and quality			
	Yield (t/ha)	Test weight (kg/hL)	Protein (%)	Screenings (%)
Short stubble (NTSR control)	5.66[a]	79.1[ab]	10.6[ab]	2.9[a]
Long stubble (NTSR)	4.98[b]	76.4[b]	11.6[a]	3.2[a]
Burn	5.85[a]	79.2[ab]	10.4[b]	3.0[a]
Remove straw	5.66[a]	77.5[ab]	10.9[ab]	3.3[a]
Cultivate (two passes)	5.56[a]	79.3[a]	10.3[b]	2.5[a]
Mean	**5.54**	**78.3**	**10.74**	**3.0**
LSD	0.45	2.9	1.05	0.8

Figures followed by different letters are regarded as statistically significant.

Long stubble (45cm) decreased yield by approximately 0.7t/ha compared with the NTSR control (short stubble) (15cm) and by 0.85t/ha compared with burnt stubbles. This reduction in yield appears to be linked with decreased DM production, particularly in the earlier stages of stem elongation.

How much the reduction in growth is a result of poor light interception compared with temperature cannot be determined from this trial, however the spindly winter growth characteristics of crops grown in long stubble would suggest a reduction in light when the sun is lower in elevation may be a strong contributor. When establishing crops between the rows of the previous crop it is important to consider stubble length in relation to the early growth of the crop.

Summary of results from three second-wheat trials

Comparing the establishment treatments that were common across all three trials (Daysdale, Yarrawonga and Dookie) revealed a small trend for increased yields with cultivation and burnt stubbles before sowing second wheat (Table 18). However none of the differences were statistically significant in the individual trials. The largest impact on second-wheat yield was stubble length at the Dookie site, where a 30cm increase in standing stubble length reduced yield by 0.7t/ha.

TABLE 18 Yield summary of the common treatments from the three large plot trials

Treatment	Yield (t/ha and % of NTSR control)						
	Trial 1 (Daysdale)		Trial 2 (Yarrawonga)		Trial 3 (Dookie)		
	(t/ha)	(% of control)	(t/ha)	(% of control)	(t/ha)	(% of control)	Mean
NTSR (control)	3.17	100	4.18	100	5.66	100	**100.0**
Burn	3.10	98	4.43	106	5.85	103	**102.3**
Cultivate (1–2 passes)	3.18	100	4.54	109	5.56	98	**102.3**
GSR (mm) (Apr–Oct)	333		373		386		

Trial 4: Henty, NSW

Key points

- Under moist mid-April sowing conditions, there was a significant yield advantage (0.45t/ha) with one shallow-pass cultivation before establishing canola, compared with crops sown directly into standing wheat stubble.
- The yield advantage of canola following a cultivation correlated to crops with higher vigour, early dry matter (DM) and greater nitrogen (N) uptake.
- There was no significant benefit to mulching the first wheat stubble before direct drilling canola.
- The addition of 40kg N/ha at sowing gave a significant yield increase to crops established directly into the first wheat stubble, but there was no significant advantage to the additional nitrogen where stubbles were cultivated or mulched.

Sowing date: 16 April 2014

Rotation: Canola following wheat

Variety: GT50 RR

Stubble: Wheat (various treatments applied)

Rainfall:
GSR: 390mm (April–October)
Summer rainfall: 85mm

Soil nitrogen: 62kg N/ha NTSR (control), 84kg N/ha multidisc in 0–60cm (31 March 2014)

Results

i) Establishment and crop structure

One-pass cultivation of the soil before establishment resulted in crops with significantly more vigour and earlier flowering in comparison to crops established with no-till full stubble retention (NTSR). Mulching the wheat straw had no effect compared with the NTSR. As NTSR with the disc drill flattened the stubble at establishment (Figure 1a versus Figure 1b), it is likely the NTSR (standing) treatment shared many characteristics with the mulched stubble; hence the lack of difference between them. The addition of 40kg N/ha did not significantly influence plant establishment, vigour or flowering. There was no evidence the addition of nitrogen influenced crop establishment or structure (Table 19).

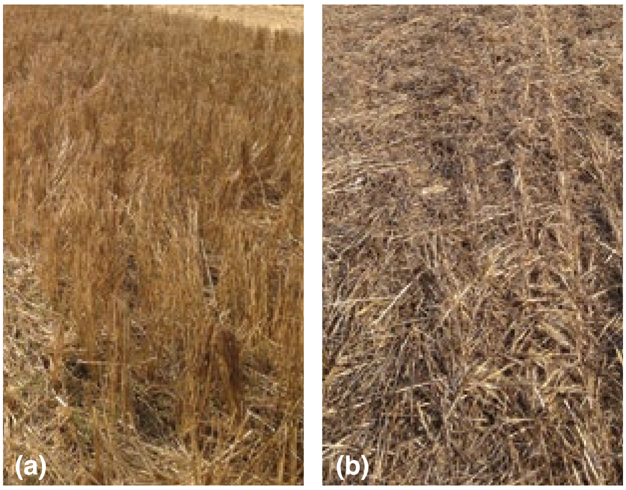


FIGURE 1 Comparison of NTSR before sowing (a) and NTSR after sowing (b)

TABLE 19 Plant counts and canopy vigour scores 21 May 2014, three leaves unfolded (GS13); raceme counts and percentage started flowering (%) 7 August 2014, yellow bud-start of flowering (GS59–61) and raceme counts 3 November 2014, harvest (GS99)

	Canopy composition (mean of nitrogen levels)				
	GS13		GS59–61		GS99
Treatment	Plants/m²	Vigour*	Flower shoots/m²	Flowering %	Raceme /m²
NTSR (control)	33^{a}	4.3^{b}	79^{b}	26^{b}	278^{a}
Mulched	35^{a}	4.2^{b}	87^{b}	33^{b}	283^{a}
Cultivated (one pass)	37^{a}	6.3^{a}	110^{a}	40^{a}	268^{a}
Mean	**35**	**4.9**	**92**	**33**	**276**
LSD	9	0.3	19	7	39
Additional nitrogen at sowing (mean of establishment)					
Nil	33^{a}	4.8^{a}	99^{a}	30^{a}	275^{a}
40kg N/ha	36^{a}	5.0^{a}	86^{a}	35^{a}	278^{a}
LSD	7	0.3	15	6	32

* Vigour — measured on a scale of 1–10 where 1 = poor vigour
Figures followed by different letters are regarded as statistically significant.

There were no significant differences in broadleaf or grass weed populations in the trial (data not shown).

ii) Dry matter production

Crops established following one-pass cultivation with the K-Line Speedtiller tended to produce higher DM throughout the season, however these differences were not significant except at the green bud assessment. (Table 20).

The addition of extra nitrogen at establishment increased DM production up until flowering, after which there was no difference.

iii) Nitrogen uptake

Nitrogen uptake by the crop was greater after cultivation when measured at green bud (Table 21). The addition of nitrogen at establishment increased nitrogen uptake up to mid-flowering, after which there was no difference.

There were low levels of leaf phoma in the trial, the disease associated with blackleg in canola (caused by fungus *Leptosphaeria maculans*), but there were no differences due to treatment (data not shown).

iv) Yield and quality

Cultivating the soil resulted in significantly higher canola yields than the NTSR control treatment (Table 22). There was no difference in yield between mulching the wheat stubble compared with sowing straight into the stubble, likely due to flattening of the NTSR stubble by the seed drill and the resultant similarities between the two treatments. When all stubble management treatments were considered, the addition of 40kg N/ha at sowing resulted in a 0.15t/ha yield difference overall, which was not significant.

When individual treatments were compared, cultivation gave a significant yield advantage (0.45t/ha) over crops

TABLE 20 Dry matter 9 July 2014, green bud (GS51); 20 August 2014, mid-flowering (GS65); 7 October 2014, mid pod set (GS75) and 21 November 2014, harvest (GS99)

Treatment	Dry matter (t/ha)			
	GS51	GS65	GS75	GS99
NTSR (control)	1.72[b]	5.32[a]	7.66[a]	9.43[a]
Mulched	1.65[b]	5.53[a]	8.41[a]	8.42[a]
Cultivated (one pass)	2.25[a]	5.67[a]	9.70[a]	10.03[a]
Mean	**1.87**	**5.51**	**8.59**	**9.29**
LSD	0.45	0.95	2.24	2.33
Additional nitrogen at sowing (mean of establishment)				
Nil	1.57[b]	4.70[b]	8.46[a]	8.76[a]
40kg N/ha	2.18[a]	6.31[a]	8.72[a]	9.83[a]
LSD	0.37	0.78	1.83	1.90

Figures followed by different letters are regarded as statistically significant.

TABLE 21 Nitrogen uptake 9 July 2014 green bud (GS51); 20 August 2014, mid-flowering (GS65); 7 October 2014, mid pod set (GS75) and 21 November 2014, harvest (GS99)

Treatment	Nitrogen uptake (kg N/ha)			
	GS51	GS65	GS75	GS99
NTSR (control)	46[b]	138[ab]	99[a]	109[a]
Mulched	41[b]	157[a]	101[a]	96[a]
Cultivated (one pass)	60[a]	125[b]	96[a]	108[a]
Mean	**49**	**140**	**99**	**104**
LSD	13	28	27	31
Additional nitrogen at sowing (mean of establishment)				
Nil	40[b]	112[b]	88[a]	94[a]
40kg N/ha	58[a]	167[a]	110[a]	115[a]
LSD	11	23	22	57

Figures followed by different letters are regarded as statistically significant.



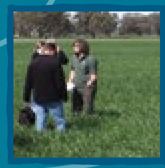


TABLE 22 Influence of establishment method (mean of nitrogen level) and nitrogen level (mean of establishment) on yield, oil content and protein at harvest (GS99), 24 November 2014

Treatment	Yield (t/ha)	Oil (%)	Protein (%)
NTSR (control)	2.22[b]	43.0[a]	22.7[a]
Mulched	2.25[b]	43.3[a]	23.1[a]
Cultivated (one pass)	2.55[a]	44.0[a]	21.9[a]
Mean	2.34	43.4	22.6
LSD	0.27	1.6	2.2
Additional nitrogen at sowing (mean of establishment)			
Nil	2.26[a]	43.6[a]	22.2[a]
40kg N/ha	2.42[a]	43.2[a]	23.0[a]
LSD	0.23	1.1	1.3

Figures followed by different letters are regarded as statistically significant.

TABLE 23 Influence of establishment method and nitrogen level on yield, oil content and protein at harvest (GS99), 24 November 2014

Treatment	Grain yield and quality	
	Yield (t/ha)	Oil (%)
NTSR (control)	2.02[c]	43.2[a]
NTSR + 40kg N/ha	2.42[ab]	42.7[a]
Mulched	2.29[abc]	43.8[a]
Mulched + 40kg N/ha	2.21[bc]	42.7[a]
Cultivated	2.48[ab]	43.7[a]
Cultivated + 40kg N/ha	2.63[a]	44.2[a]
Mean	**2.34**	**43.4**
LSD	0.36	1.85

Figures followed by different letters are regarded as statistically significant.

established directly into the standing wheat stubble (NTSR control treatment) (Table 23). The addition of 40kg/N ha significantly increased the yield of the NTSR control crop; with the mulched and cultivated crops the effect of nitrogen addition on yield was non-significant.

Commercial application

When making stubble management decisions keep in mind these results are from one year of data only.

With wetter conditions and an early break there was a significant yield advantage to canola established following cultivation compared with the NTSR control treatment. The yield advantage of canola following cultivation correlated to better vigour, higher early DM production and nitrogen uptake.

There was evidence that additional nitrogen at sowing could benefit NTSR crops under the moist mid-April conditions.

Although there was no evidence to suggest that mulching first wheat stubbles increased the subsequent canola crop productivity, it should be emphasised that direct drilling into the stubbles under these moister conditions (and with this drill on narrow row spacings) flattened the stubble rather than leaving it standing. Under drier conditions, or with a wider row spacing, the stubble may have stayed more erect following sowing, which could result in greater early shading and potentially impact on early growth, as was found to be the case at Dookie with second wheat establishment.

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