# Summer cover crops in short fallow - do they have a place in central NSW?

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**Key words**

cover crop, stubble cover, ground cover, short fallow

**GRDC code**

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**Take home messages**

- Summer cover crops reduced the winter cash crop (wheat) grain yield by up to 1.5 t/ha at Canowindra and 0.6 t/ha at Parkes
- Grain yield losses were minimised by spraying out the cover crop early
- The grazing value ($/ha) generated from the cover crop more than compensated for the grain yield reduction based on current commodity prices
- Pros of summer cover crops include increased ground cover, reduced soil erosion from wind and water, cooler and more consistent soil temperatures, improved autumn sowing conditions, valuable summer forage for mixed farming operations, quicker soil water recharge compared with bare ground, reduced herbicide applications over the summer fallow, and improved total soil carbon % and assumed microbial activity
- Cons of summer cover crops include reduced mineral nitrogen and reduced grain yield for the following winter cash crop, increased risk of soil water deficit in low rainfall years (or greater reliance on in-crop rainfall), additional seed costs, patchy establishment of summer cover crop due to rapidly drying soils, high herbicide rate required to terminate cover crop, and increased disease risk (stubble and soil) due to green bridge for the following winter cash crop
- Risks associated with cover crops are reduced by: longer fallow period post cover crop for soil moisture recharge and mineralisation of cover residue; incorporating livestock within the system to convert surplus biomass to $/ha; seasons with high rainfall; additional nitrogen fertiliser application for winter cash crop
- The optimum 'crop type selection' and 'spray out timing' will vary depending on individual paddock and enterprise goals.

**Background**

Dust storms have been a common sight in central NSW in the summer of 2019/2020 due to the combination of drought and low ground cover. Ground cover levels have been on a decline since 2017 with residual stubble decomposing over this time, and limited opportunity to grow fresh biomass over the past 2-3 years. Factors further reducing ground cover levels include growing low biomass pulse crops (e.g. chickpeas), incorporation of lime, grazing stubbles and baling of failed winter crops. Both the magnitude and duration of the current dry period has been unparalleled and is highlighting the value of ground cover.

The benefits of cover crops to protect the soil from wind or water erosion in low stubble scenarios is well understood, however the use of cover crops as a technique to improve water infiltration and storage to improve grain yield for the following winter cash crop is less clear. Recent GRDC funded research (McMaster 2015) has demonstrated that 50% of yield potential can be attributed to summer rainfall and summer fallow management as a result of increased stored water and nitrogen (N). Water and nitrogen increase grain yield through grain number (more tillers and more grains per head) and grain size, with a return on investment of controlling summer weeds between $2.20 and $7.20 ha for every dollar invested.

The primary purpose of these experiments was to evaluate if there is a net water gain to the subsequent winter cash crop (wheat) following a summer cover crop, and the associated result on grain yield. The secondary purpose of this project was to evaluate the impact of various spray-out timings (early, mid and late) and crop-types (including single species, mixed species and summer weeds) on the farming system, including grazing value of cover ($), crop nutrition (mineral N and total carbon %), disease pressure (stubble and soil), and soil temperature.

**Method**

Two sites with zero ground cover were selected in central NSW at Canowindra (high rainfall zone – central east (CE) slopes) and Parkes (medium rainfall zone – central west (CW) plains). Each site consisted of a short and long fallow treatment and the experiment design was a randomised block with 4 replications. Individual plot size was 10m X 10m across all experiments. The following report provides results from the short fallow experiments only, and includes treatment combinations of four cover crops, three spray-out timings and one control (bare ground, weed-free). The summer cover crops were sown using a knife point press wheel plot seeder at 30cm row spacing and the subsequent winter cash crop was sown with a single disc plot seeder (30cm row spacing) due to trash flow requirements. Fertiliser was applied with the seed, at a rate of 50 kg/ha of mono ammonium phosphate (MAP) with the cover crop and 50 kg/ha MAP with the winter crop. The summer cover crops were sown on 26 November (2018) at Canowindra, and 9 December (2018) at Parkes. The subsequent winter crop (Wheat – cv Mustang(b)) was sown on 18 May at Canowindra, and 25 May at Parkes.

***Short fallow trial (6-month fallow – November 2018 to April 2019)***

Treatment details:

- Treatment 1: Cover crop types = cow peas, forage sorghum, mixed species and summer weeds
- Treatment 2: Spray out timings = 50, 80 and 110 days after sowing the cover crop (DAS)
- Treatment 3: Control = bare ground kept weed-free.

The mixed species included cow peas, lab/lab, forage sorghum, millet, tillage radish and sunflower.

**Results and discussion**

***Seasonal conditions and crop establishment***

**Table 1.** Monthly rainfall and long-term average (LTA) rainfall for Canowindra and Parkes, 2019.

| Month | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Canowindra** | | | | | | | | | | | | | |
| Rainfall (mm) | 39 | 34 | 45 | 53 | 1 | 33 | 34 | 13 | 24 | 21 | 20 | 17 | 7 |
| LTA (mm) | 53 | 57 | 50 | 49 | 40 | 44 | 48 | 50 | 48 | 42 | 51 | 49 | 53 |
| **Parkes** | | | | | | | | | | | | | |
| Rainfall (mm) | 21 | 28 | 23 | *32* | 0 | 29 | 25 | 13 | 10 | 18 | 27 | 11 | 7 |
| LTA (mm) | 54 | 58 | 50 | 46 | 43 | 44 | 50 | 51 | 50 | 46 | 56 | 51 | 54 |

**Table 2.** Seed rate, seed cost and field establishment of summer cover crops at Canowindra and Parkes, 2019.

| Treatment | | Seed rate | Seed size | Seed cost | Seed cost | Canowindra | | Parkes | |
|---|---|---|---|---|---|---|---|---|---|
| | | (kg/ha) | Seeds/kg | (per kg) | (per ha) | (Plants $m^2$)[b] | Est (%) | (Plants $m^2$)[b] | Est (%) |
| Forage sorghum | | 9 | 32100 | \$5.20 | \$46.80 | 26.8 | 93% | 22.8 | 79% |
| Cow pea | | 16 | 9500 | \$3.90 | \$62.40 | 12.5 | 82% | 12.6 | 83% |
| Mixed species[a] | forage sorghum | 2 | 32100 | \$5.20 | \$10.40 | 4.9 | 76% | 5.2 | 81% |
| | millet | 5 | 124000 | \$2.50 | \$12.50 | 19.5 | 31% | 11.3 | 18% |
| | cow pea | 4 | 9500 | \$3.90 | \$15.60 | 2.6 | 68% | 3.5 | 92% |
| | lab lab | 4 | 4300 | \$4.00 | \$16.00 | 1.5 | 87% | 1.5 | 87% |
| | sunflower | 1 | 21052 | \$20.00 | \$20.00 | 1.3 | 62% | 0.6 | 29% |
| | tillage radish | 1 | 44642 | \$9.50 | \$9.50 | 5 | 112% | 3.7 | 83% |

[a] = Total seed cost for the mixed species treatment was \$84/ha
[b] = Actual plants established per $m^2$

***Cover crop biomass***

*Canowindra site*

Biomass production ranged from 0.07 to 10.8 t/ha (Table 3) and was influenced by crop type ($P$<0.001), spray-out timing ($P$<0.001) and the interaction between both ($P$<0.001). Highest biomass produced across the site was 10.8 t/ha of forage sorghum (sprayed out late), compared with the lowest biomass produced by summer weeds (sprayed out early) with 0.07 t/ha.

On average across crop-types, forage sorghum (6.5 t/ha) and mixed species (3.4 t/ha) produced much higher biomass than the cow pea (1.3 t/ha) and summer weed (1 t/ha) treatments. Average biomass production further increased as spray-out timing was delayed from early, mid to late with a respective increase of 1.33 t/ha, 2.99 t/ha and 4.85 t/ha. Nitrogen fertility at this site was high (refer to crop nutrients section) and might explain why biomass production was relatively high at this site. Refer to Table 3 for individual biomass treatment results and Table 5 for feed test results.

*Parkes site*

Biomass production varied from 0.10 to 2.09 t/ha (Table 4) and was influenced by crop type ($P$<0.001), spray out timing ($P$=0.005) and the interaction between both ($P$=0.05). Biomass results were much less than Canowindra, yet the treatments still ranked similarly with forage sorghum (sprayed out late) producing the highest biomass of 2.09 t/ha, and summer weeds (sprayed out early) the lowest at 0.10 t/ha.

On average, forage sorghum (1.48 t/ha) produced more biomass than mixed species (0.94 t/ha), cow pea (0.36 t/ha) and summer weed (0.09 t/ha) treatments. Biomass increased as spray-out timing was delayed from early (0.33 t/ha) to mid (0.95 t/ha), but there was no further increase from mid to late (0.87 t/ha) spray-out timing. Refer to Table 4 for individual biomass treatment results and Table 6 for feed test results.

Interestingly, the millet seed was much less robust than forage sorghum due to lower plant establishment (Table 2) and crop growth appeared to be visually more affected by the higher temperatures than the forage sorghum. For example, the millet foliage turned limp and floppy whilst the forage sorghum foliage became spikier and more erect (similar to a drought stressed wheat crop). Consequently, millet contributed very little biomass in the mixed species treatment.

***Soil temperature at 10cm depth***

*Canowindra site (11 April at 3pm)*

The average soil temperature was 22.2°C and ranged from 18.9°C to 24.3°C. Soil temperature reduced as cover crop biomass increased and was affected by crop type ($P$<0.001), spray-out timing ($P$<0.001) and their interaction ($P$<0.015).

On average, the higher biomass crop types had cooler soil temperatures, with forage sorghum and mixed species being a respective 4.4°C and 3.8°C cooler than the bare ground, cow pea and summer weed treatments. There was no significant difference between the lower biomass crop types of cow peas, summer weeds and bare ground treatments. As spray out timing was delayed, the early and mid-timings were 1.3°C and 2.9°C cooler than the bare ground, respectively. Interestingly, there was no additional cooling effect from the mid and late spray-out timing. Refer to Table 3 for individual treatment results.

Additionally, higher biomass plots were cooler and provided a more consistent soil temperature around the mean when compared to bare ground (data not shown). During the period of 8 March to 20 May, when the bare ground treatment had a range (difference between the daily minimum and maximum temperature) of 10°C or 5°C, the forage sorghum (late spray-out) had a respective range of 6.4°C or 2.5°C.

Cooler soil temperatures would be an indication that evaporation rates were initially reduced under the higher biomass plots. Aside from soil water, higher biomass residues could enable earlier sowing opportunities for winter cereal grazing crops as cooler soil temperatures improve coleoptile length and establishment. Soil temperatures greater than 25°C can reduce crop establishment in winter cereals (Edwards 2006). Conversely, the more consistent soil temperatures of the higher biomass plots could potentially enable summer grain crops such as sorghum to be sown into cooler temperatures than previously practised (Serafin *pers. comm*).

*Parkes site (measured 12 April at 3pm)*

Parkes was 4.7°C hotter than Canowindra, with an average soil temperature of 26.9°C, ranging from 25.8°C to 27.6°C. Soil temperature was significantly affected by crop type ($P$=0.013), and the interaction between crop type and spray-out timing ($P$=0.052). Spray out timing was not significant ($P$=0.697). Parkes is a hotter region which explains the higher soil temperatures; however, the smaller range of soil temperatures is more of an indication of less biomass produced at this site.

Forage sorghum was 0.8°C cooler than the bare ground treatment. There were no significant differences between the lower biomass plots of bare ground, mixed species, cow peas or summer weed treatments. Refer to Table 4 for individual effects.

***Crop nutrients (mineral nitrogen and total carbon %)***

*Canowindra site*

Average mineral nitrogen (N) was measured before sowing the winter crop on 1 April. Sampling depth was 1.2 metres and the site average was 272 kg N/ha, and ranged from 195 kg N/ha to 343 kg N/ha. Mineral N was influenced by crop type ($P$=0.018) and spray out timing ($P$=0.053), but the interaction between both was not significant ($P$=0.676). Site mineral N was highly variable within treatments, and possibly a legacy effect from the previous canola crop (2018) that was grazed out due to drought.

Highest mineral N was achieved in the bare ground treatment (320.6 kg N/ha), and on average reduced by 79 kg N/ha for the higher biomass crop-types such as forage sorghum and mixed species, and by 46 kg N/ha and 10kgN/ha for the lower biomass crop-types such as cow peas and summer weeds, respectively. Cow peas had little positive effect on soil nitrogen levels and this may be due to: poor nodulation caused from the high temperatures; lazy nodulation due to high nitrogen levels.

Average total carbon percentage was 2% in the 0-10cm soil depth and ranged from 1.75% to 2.25%. Compared with the bare ground treatment (1.76%), total carbon increased by 0.36%, 0.33%, 0.22% and 0.11% in the forage sorghum, mixed species, summer weed and cow pea treatment, respectively. The average total carbon percentage in the 10–30cm was 0.64%, and there were no treatment effects.

*Parkes site*

Average mineral N was 103.2 kg N/ha and ranged from 61.3 kg N/ha to 152.8 kg N/ha. Mineral N was reduced as the cover crop biomass increased, and was affected by crop type ($P$=0.019), but not by spray-out timing ($P$=0.093) or interaction of both ($P$=0.414)

The bare fallow treatment had the highest mineral N with 152.8 kg N/ha, and then reduced on average by 69.5 kg N/ha, 61.1 kg N/ha, 50 kg N/ha and 34.6 kg N/ha for forage sorghum, mixed species, cow pea and summer weed treatments respectively. Refer to Table 4 for individual effects.

The average total carbon percentage was 1.01% in the 0–10cm depth, and 0.48% in the 10–30cm depth. There was not enough biomass produced to alter total carbon at either depth.

***Soil water accumulation***

*Canowindra site*

As expected, over the summer period the various cover crops extracted moisture from the soil profile to grow biomass. After cover crop termination there was approximately a 50mm water deficit between the driest and wettest plot (Figure 1). Soil water levels were affected by crop-type (Figure 2a) and spray-out timing (Figure 2b), but no interaction between the two .

The higher biomass crop-types such as forage sorghum and mixed species extracted more moisture than lower biomass crops such as cow pea and summer weeds (Figure 2a). Additionally, spray-out timing also impacted soil water with the mid and late spray-out timing being approximately 30mm dryer than the early spray-out (Figure 2b). Despite the soil water deficit at cover crop termination, the higher biomass plots recharged quicker than the bare ground treatment resulting in no statistical difference in soil moisture from the 16 April to 12 November. The rate of recharge was a surprising result and warrants further investigation to determine if the higher biomass treatment would overtake the bare fallow moisture levels in a normal year.

The legacy effect of the various forms of ground cover will be monitored throughout the 2020 season.

Summer weed results (soil water) are not included due to the uneven nature of summer weed establishment that was not picked up by the soil neutron probe.

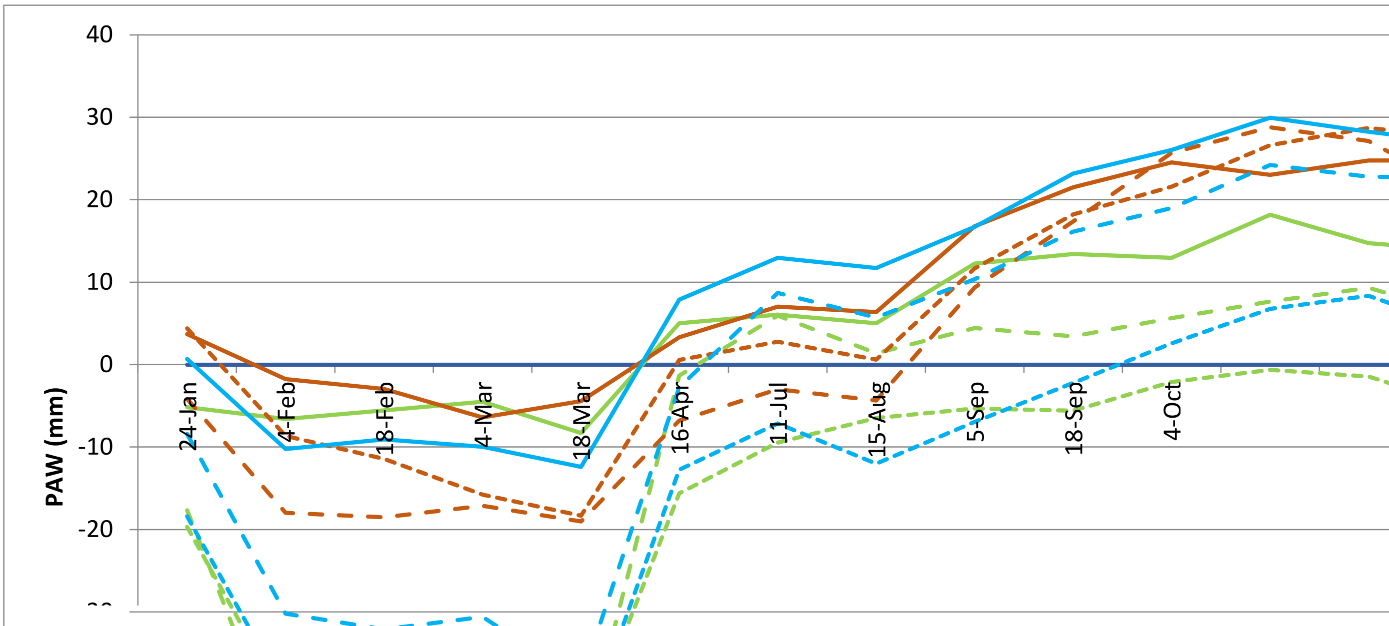


**Figure 1.** Individual treatment effects on soil water accumulation (+/- mm PAW) compared with the bare ground control at Canowindra NSW

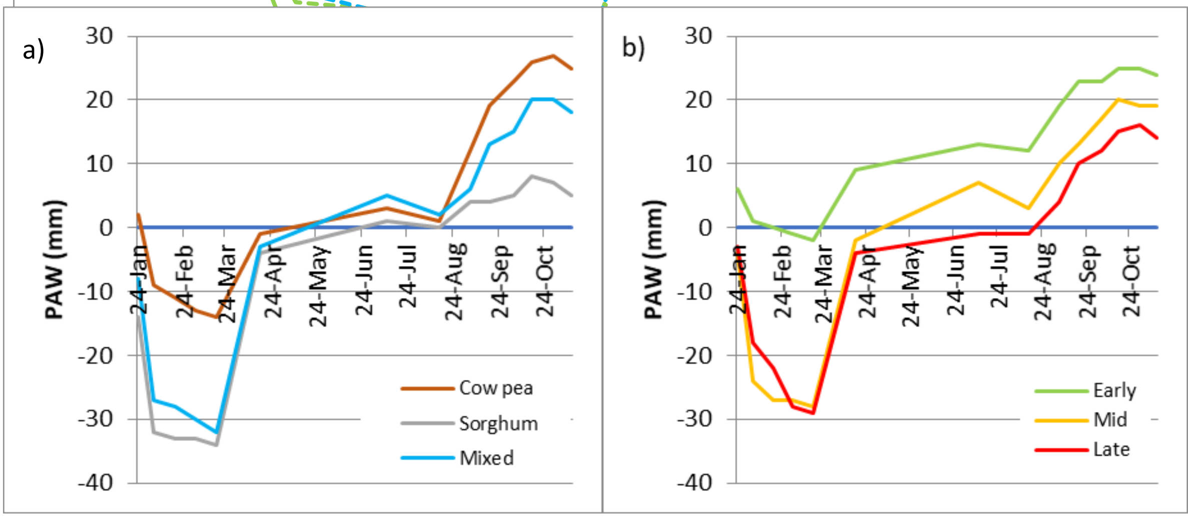


**Figure 2.** Main effects of cover crop-type (a) and spray-out timing (b) on soil water accumulation compared with the bare ground control at Canowindra NSW.

***Predicta® B results – (stubble and soil pathogens)***

*Canowindra site*

Diseases that were significantly affected by the various cover crops and spray out timings included: Take all; *Pythium clade* F; *Pyrenophora tritici repentis*; *Pratylenchus neglectus*; *Macrophomina phaseolina* and *Fusarium* spp. Results will be included in a separate report

*Parkes site*

Diseases that were significantly affected by the various cover crops and spray out timings included: Take all; *Pythium clade* F; *Pratylenchus thornei*; *Macrophomina phaseolina*; *Didymella pinodes* and *Fusarium* spp.

***Grain yield results***

*Canowindra site*

The average grain yield was 1.91 t/ha, and ranged from 1.13 to 2.93 t/ha. Grain yield was affected by crop-type ($P<0.001$), spray-out timing ($P<0.001$) but not the interaction between both ($P=0.459$).

The highest grain yield (2.93 t/ha) was from the bare ground treatment, and on average reduced by 1.4 t/ha, 1.2t/ha, 1.2 t/ha and 0.6 t/ha from the cow pea, forage sorghum, mixed species and summer weed treatments, respectively. Grain yield reduced as spray out timing was delayed with early, mid and late yielding 2.43 t/ha, 1.72 t/ha and 1.33 t/ha, respectively. Interestingly, the cow peas provided little benefit for the following winter cash crop.

*Parkes site*

The Parkes site was low yielding with an average grain yield of 0.35 t/ha, ranging from 0.07 to 0.71 t/ha. Grain yield was affected by crop type ($P<0.001$), spray out timing ($P=0.003$) and the interaction between crop type and spray out timing ($P=0.032$).

The highest grain yield (0.71 t/ha) was in the control which was weed-free, bare ground, and on average, grain yield reduced by 0.56 t/ha, 0.51 t/ha, 0.33 t/ha and 0.04 t/ha following forage sorghum, mixed species, cow pea and summer weeds, respectively. Compared with the bare ground treatment, grain yield reduced by 0.27 t/ha and 0.39 t/ha following the early and mid-spray out timing, respectively. There was no further grain yield loss between mid and late spray-out timing. Refer to Table 4 for individual effects.

**Table 3.** Individual treatment results from short fallow cover crop experiment – Canowindra NSW.

| Crop type | Spray-out timing | Ground cover biomass (t/ha) | Soil temperature (°C) | Mineral N (kgN/ha) | Total carbon 0–10cm (%) | Total carbon 10–30cm (%) | Wheat grain yield (t/ha) |
|---|---|---|---|---|---|---|---|
| Bare | Weed-free | 0 | 24.3 | 321 | 1.76 | 0.637 | 2.93 |
| Cowpea | Early | 0.71 | 24.2 | 286 | 1.75 | 0.608 | 2.26 |
| | Mid | 1.5 | 23.6 | 275 | 1.87 | 0.623 | 1.23 |
| | Late | 1.73 | 23.5 | 266 | 2 | 0.675 | 1.23 |
| Forage sorghum | Early | 2.8 | 21.7 | 288 | 1.93 | 0.683 | 2.45 |
| | Mid | 5.9 | 18.9 | 195 | 2.17 | 0.595 | 1.56 |
| | Late | 10.8 | 19.3 | 245 | 2.26 | 0.738 | 1.13 |
| Mixed species | Early | 1.71 | 22.2 | 274 | 2.01 | 0.615 | 2.15 |
| | Mid | 4.03 | 19.4 | 241 | 2.14 | 0.55 | 1.76 |
| | Late | 4.51 | 20 | 212 | 2.12 | 0.72 | 1.19 |
| Summer weeds | Early | 0.1 | 24.1 | 343 | 2.07 | 0.608 | 2.84 |
| | Mid | 0.51 | 23.6 | 316 | 1.92 | 0.69 | 2.33 |
| | Late | 2.32 | 23.8 | 276 | 1.95 | 0.605 | 1.75 |
| *P value* | | *<0.001* | *<0.001* | *0.03* | *0.15* | *0.907* | *<0.001* |
| *5% Lsd* | | *1.1* | *1.1* | *80* | *0.36* | *0.236* | *0.5* |

**Table 4:** Individual treatment results from short fallow cover crop experiment – Parkes NSW.

| Crop type | Spray-out | Cover Biomass (t/ha) | Soil temperature (°C) | Mineral N (kgN/ha) | Total carbon 0–10cm (%) | Total carbon 10–30cm (%) | Grain yield (t/ha) |
|---|---|---|---|---|---|---|---|
| Bare | Weed free | 0 | 27.1 | 153 | 1.01 | 0.49 | 0.71 |
| Cowpea | Early | 0.27 | 27.1 | 126 | 1 | 0.51 | 0.48 |
| | Mid | 0.4 | 27.3 | 82 | 0.99 | 0.49 | 0.33 |
| | Late | 0.42 | 27 | 100 | 0.95 | 0.54 | 0.34 |
| Forage sorghum | Early | 0.47 | 26.5 | 104 | 1.02 | 0.43 | 0.28 |
| | Mid | 1.86 | 25.8 | 86 | 1.12 | 0.51 | 0.1 |
| | Late | 2.09 | 26.8 | 61 | 1.07 | 0.57 | 0.07 |
| Mixed species | Early | 0.47 | 27.2 | 96 | 1.01 | 0.45 | 0.37 |
| | Mid | 1.42 | 27 | 84 | 0.97 | 0.45 | 0.15 |
| | Late | 0.94 | 26.1 | 95 | 1.08 | 0.46 | 0.09 |
| Summer weeds | Early | 0.1 | 27 | 119 | 0.97 | 0.5 | 0.63 |
| | Mid | 0.12 | 26.9 | 116 | 0.1 | 0.43 | 0.62 |
| | Late | 0.04 | 27.6 | 120 | 1.02 | 0.46 | 0.77 |
| *P value* | | *<0.001* | *0.019* | *0.015* | *0.655* | *0.851* | *<0.001* |
| *5% Lsd* | | *0.754* | *0.9* | *42* | *0.153* | *0.159* | *0.159* |

**Table 5.** Cover crop feed quality results and potential lamb production results – Canowindra.

| Crop type | Spray out time | Yield (t DM/ha) | Metabolisable energy (MJ/kg DM) | Crude protein (%) | Liveweight gain (kg/ha) [1] | Value of gain ($/ha) [2] |
|---|---|---|---|---|---|---|
| Cowpea | Early | 0.7 | 10.7 | 23.3 | 85 | 297 |
| | Mid | 1.5 | 10.2 | 17.6 | 161 | 563 |
| | Late | 1.7 | 10.1 | 17.6 | 176 | 617 |
| Forage sorghum | Early | 2.8 | 10.2 | 14.5 | 300 | 1051 |
| | Mid | 5.9 | 10.3 | 10.2 | 522 | 1827 |
| | Late | 10.8 | 11.1 | 7.9 | 1062 | 3716 |
| Mixed species | Early | 1.7 | 11.0 | 19.9 | 228 | 799 |
| | Mid | 4.0 | 10.1 | 12.7 | 400 | 1399 |
| | Late | 4.5 | 10.4 | 11.3 | 469 | 1643 |

1. Crossbred wether lambs (Border Leicester x Merino or Dorset x Merino), 6 months old, 30 kg live weight utilising 80% of the crop grown.
2. Lamb value of $3.50 per kg.
3. These results are based on feed test results conducted from dry matter samples, sheep were not actually grazed.

**Table 6.** Cover crop feed quality results and potential lamb production results – Parkes.

| Crop type | Spray out time | Yield (t DM/ha) | Metabolisable energy (MJ/kg DM) | Crude protein (%) | Liveweight gain (kg/ha) [1] | Value of gain ($/ha) [2] |
|---|---|---|---|---|---|---|
| Cowpea | Early | 0.3 | 11.1 | 24.7 | 37 | 130 |
| | Mid | 0.4 | 10.0 | 23.0 | 40 | 138 |
| | Late | 0.4 | 10.9 | 20.3 | 53 | 185 |
| Forage sorghum | Early | 0.5 | 10.5 | 12.6 | 50 | 176 |
| | Mid | 1.9 | 11.0 | 12.8 | 234 | 818 |
| | Late | 2.1 | 10.5 | 9.7 | 218 | 761 |
| Mixed species | Early | 0.5 | 10.7 | 16.2 | 56 | 196 |
| | Mid | 1.4 | 10.9 | 13.9 | 177 | 619 |
| | Late | 0.9 | 10.6 | 11.3 | 100 | 352 |

1. Crossbred wether lambs (Border Leicester x Merino or Dorset x Merino), 6 months old, 30 kg live weight utilising 80% of the crop grown.
2. Lamb value of $3.50 per kg.
3. These results are based on feed test results conducted from dry matter samples; sheep were not actually grazed.

**Conclusion**

Summer cover crops provide a series of pros and cons for the following winter cash crop. Individual paddock goals, enterprise mix, rainfall and commodity prices will ultimately determine if the pros outweigh the cons. There needs to be a clear understanding of how the cover crop will integrate and benefit the broader farming system.

Soil water recharge following a cover crop is much quicker than bare ground, yet a soil water deficit would occur if no rain falls after cover crop termination. Even in a wet year, there is likely to be a nitrogen deficit for the following winter cash crop that would require correcting with additional nitrogen fertiliser. Presumably, as total carbon % increases, the reliance on supplementary nitrogen could reduce over time with an understanding this will take a number of years.

Grain only cropping operations with short fallows (6 month) are likely to increase the financial risk profile when growing summer cover crops, as yield was reduced at both experiment sites following a cover crop compared with bare ground. Management techniques that retain stubbles and control summer weeds are still considered best practise, as no additional water is used to grow the biomass. However, the use of cover crops as a 'one off' technique to protect the soil from wind or water erosion in low ground cover scenario's may be warranted but considered a 'one off' rather than regular annual management operation.

Conversely, mixed farming enterprises have good reason to capitalise on the increased biomass of a summer cover crop given the current prices for red meat (Tables 5 and 6). According to these results, the grazing value would more than compensate for the winter crop grain yield penalty. Nutrients such as nitrogen would need to be adequate to support such a high output system, however the additional income from the livestock enterprise would compensate for the additional nutritional expenses.

Whilst not absolute, disc seeders are an integral part of the cover cropping system as they improve crop establishment in rapidly drying soils (associated with summer plantings) and provide for the high trash flow requirements of the cover crop system. A patchy cover crop will be no better than a weedy fallow, so crop establishment is an important factor. Consideration needs to be given to seeding depth, particularly for multi-species mixes as the seed size range within the mix will determine the potential seeding depth. For example, millet needs to be sown shallow, but forage sorghum and cow peas can be sown much deeper.

The improved rate of soil water recharge was interesting, and the legacy effects will be monitored throughout the 2020 season to evaluate if the higher biomass treatments overtake the bare fallow.

A separate report will detail results from summer cover crops in LONG fallow paddock scenarios.

### Useful resources

https://grdc.com.au/resources-and-publications/all-publications/publications/2019/blackleg-management-guide

### References


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