Increasing plant species diversity in cropping systems

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Key points

- During 2019, a range of winter crops, including wheat and field peas, were planted at a trial site in Burramine, Victoria, as part of a larger, long-term project looking at increased diversity in cropping systems.
- The 2019 winter crop trial provided results for biomass accumulation, crop yield and soil water use for the wheat and wheat undersown with sub-clover treatments.
- Undersowing wheat with sub-clover at a rate of 4kg/ha did not affect wheat yields, probably due to the small amount of DM the sub-clover produced (60kg/ha).
- Summer cover crops were established during January 2020, with the multispecies mix (sorghum, millet, forage rape, tillage radish) producing more biomass and depleting more soil water than the buckwheat and medic mix before being terminated after eight weeks of growth.

Background

Cropping systems in Australia can have limited species diversity, which has been exacerbated by declining legume use over the past decade. The diversification of crop rotations and/or the integration of green manures (including cover crops) can have positive benefits for soil health compared to monocultures, or where break crops are used minimally. Increasing plant diversity is more likely to enhance the species richness of soil biota through providing more diverse litter deposition, exudates, rooting patterns and plant associations.

To help address a lack of species diversity in the region, Riverine Plains Inc has established a long-term (five-year) trial site at Burramine as part of a national Cooperative Research Centre for High Performance Soils (Soil CRC) project, led by Southern Cross University.

The trial is assessing the viability of integrating diverse species into the farming system, as either winter rotation crops (or green/brown manures) or as summer cover crops, within the constraints of soil water and weed pressures. These trials will investigate a range of rotation options for improving soil function and, ultimately, grain yields and farm profitability. Soil function will be assessed by measuring soil microbial communities, their structure and enzyme activities, as well as mineralisation rates of nutrients (nitrogen [N], carbon [C], phosphorus [P]), through the decomposition of litters, root debris and soil organic matter over time.

Further, the Burramine trial evaluates how green manure crops, cover crops (crops grown over summer primarily for the benefit of the soil rather than for yield), intercrops (where multiple crops are sown but only one is taken to harvest) and companion crops (where multiple species of crop are grown at the same time and are all taken through to harvest) can affect soil functionality.

Aim

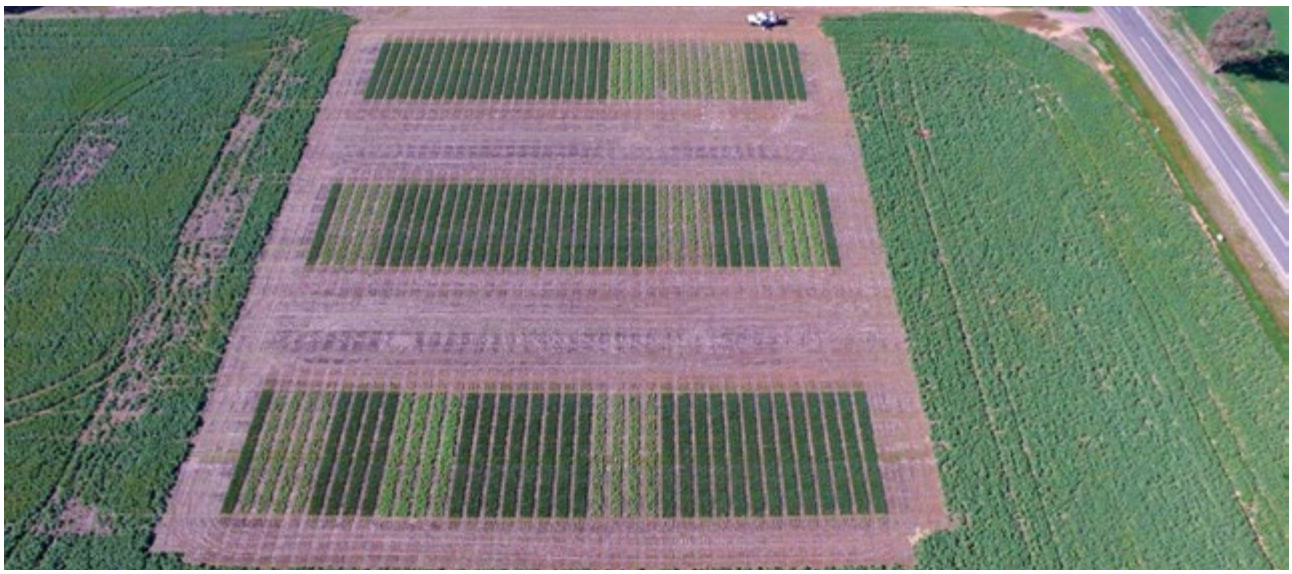
Although the cereal–oilseed–legume rotation offers advantages in terms of disease control, microbial abundance and nutrient transformation, there is little incentive for growers in southern cropping systems to increase plant diversity by growing alternative winter crops. This project aims to investigate other options to increase plant diversity, such as summer cover cropping, intercropping or companion cropping, and to examine their impacts on soil function and winter crop yields.

Method

A field trial spanning three growing seasons (winter-summer-winter) was established at Burramine, Victoria, during autumn 2019. A total of 9 different rotational treatments were established based around the core wheat–canola rotation growers in the area typically employ.

The 2019 winter treatments included wheat, an intercropping treatment with wheat undersown with sub-clover, field peas for grain, a pulse brown manure treatment (field peas) and a brown manure mix (field peas + tillage radish) (Table 1). All plots were sown on 21 May 2019 using a randomised block design, with plots measuring 8m x 18m.

The wheat undersown with sub-clover treatment aimed to investigate potential root interactions between the species and the diversity of soil microbes surrounding the wheat roots by the sub-clover, with the wheat and sub-clover both sown in the same row. The sub-clover was sown at a rate



Drone image of site, taken on 15 August, 2019. Photo courtesy Jason Condon.

TABLE 1 Full list of treatments, crop rotation and 2019 yield results

Treatments	2019 winter crop	2019 winter crop yield (t/ha)	2020 summer cover crop	2020 winter crop
Control (wheat–canola)	Wheat (cv Trojan)	1.36	-	Canola
Pulse–canola–wheat	Field peas (cv Morgan)	0.85	-	Canola
Brown manure (pulse)	Field peas (cv Morgan)	n/a	-	Canola
Brown manure (mix)	Field peas (cv Morgan + tillage radish (cv Tillage Radish)	n/a	-	Canola
Companion crop	Wheat (cv Trojan)	1.38	-	Canola + peas (peola)
Intercropping (undersown)	Wheat (cv Trojan) + sub-clover (cv Riverina)	1.29	-	Canola
Cover crop mix 1	Wheat (cv Trojan)	1.42	Medic and buckwheat	Canola
Cover crop mix 2	Wheat (cv Trojan)	1.28	Sorghum (cv Crown), millet (cv Shirohie), forage rape (cv Greenland) and tillage radish (cv Tillage Radish)	Canola
Maximum diversity	Wheat (cv Trojan)	1.39	Sorghum (cv Crown), millet (cv Shirohie), forage rape (cv Greenland) and tillage radish (cv Tillage Radish)	Canola + peas (peola)

of 4kg/ha and was not intended to produce large quantities of fixed nitrogen.

The sub-clover was terminated via herbicide application on 25 September, 2019, to allow the wheat to develop without competition for nutrients and water.

The winter crop trial was harvested on 13 December, 2019 using a plot harvester, with yields measured using a weigh cell. Because the wheat plots were harvested before the sowing of the 2020 summer cover crops, the wheat-only treatments (to be planted to summer crops) were effectively the same as the control treatment during the 2019 season.

Water use by the wheat plots (controls) and the wheat under-sown with sub-clover treatment was calculated using the equation:

$$Water\ use\ (mm) = P + I + SWD$$

Where, P is precipitation (mm), I is irrigation (mm) and SWD is soil water depletion (mm) in the 90cm profile (SWD was measured as the difference between the gravimetric soil water content at sowing and at harvest). Soil samples were taken in increments of 10cm and 20cm up to 30cm and thereafter in 30cm increments to a depth of 90cm

using a hydraulically operated soil sampler. Deep drainage and runoff were considered negligible and were assumed zero. Due to a deep ground water table, capillary rise was also considered zero.

Following a significant rainfall event, three of the wheat-only treatment plots sown during 2019 were sown to one of two summer cover-crop mixes on 16 January, 2020, as outlined in Table 1. The plots were sown to either; Cover crop mix 1 (buckwheat and medic) or Cover crop mix 2 (fodder rape, tillage radish, sorghum and millet) (Table 1). The site did not receive significant rainfall between the 2019 trial harvest until just prior to 2020 summer crop sowing, which meant the site was free of weeds and did not require further preparation. Crops were sown into the previous years' crop rows (to allow for inter-row sowing of the 2020 winter crop). The summer cover crops were sprayed out with glyphosate on 18 March 2020 to prevent seed set and to allow time for any chemical residues to breakdown before sowing the 2020 winter crop.

Soil testing was carried out throughout the 2019 cropping season, as well as post-harvest, to determine whether the presence of sub-clover had any impact on soil biological function or on soil disease levels (data not presented).

During autumn 2020, the entire trial site was sown to either canola or 'peola' (a canola and pea companion crop), representing the second (canola) phase of the wheat–canola rotation. A range of measurements will be taken during 2020 to determine the effect of treatments on the yield of the canola and 'peola'. Additional measurements will also investigate whether summer cover crops provide more benefit if the summer cover crop species are from different plant families than the winter crops grown in the rotation (although it may be that the water use by the summer cover crop species is actually the key determinant of subsequent winter crop yield, rather than the plant family). Results from 2020 will be reported in next year's edition of *Research for the Riverine Plains*.

During 2021, the site will revert back to the cereal phase of the rotation, with selected plots sown to treatments having greater diversity. Actual species determination for the remaining years of the trial will be subject to crop performance during 2020 and with consideration to the specific range of weeds, pests or diseases that will require active management.

The limited range of data from the first year of the trial means this report mainly compares the results from the wheat treatments sown during 2019 with the wheat undersown with sub-clover treatment.

Results and comments

Biomass at flowering and water use at harvest

Biomass accumulation was measured as dry matter (DM) at flowering for the wheat-only (control) and wheat undersown with sub-clover treatments. The wheat-only (control) treatment produced 1.76t/ha DM, compared with 1.95t/ha DM where wheat was undersown with sub-clover (Figure 1a), where the sub-clover accounted for about 0.06t/ha DM. Although the biomass in the wheat undersown with sub-clover treatment was 10 per cent higher than the control, this was not statistically significant. Similarly, crop water use (measured by soil coring at harvest) differed between the two treatments (Figure 1b).

Grain yields for wheat and wheat undersown with sub-clover

Wheat-only (control) yields were about 1.3t/ha, which is not significantly different to the yield of wheat undersown with sub-clover treatment (Figure 2). However, at higher sowing rates sub-clover could compete with wheat for water, nutrients or light, which would be expected to have a greater yield impact on the wheat.

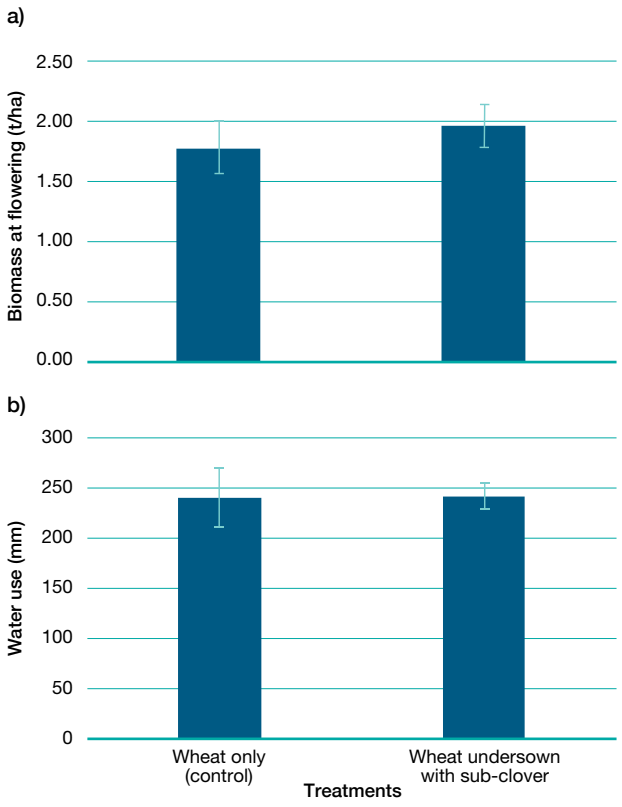


FIGURE 1 Biomass at flowering (a) and water use at harvest (b) including evaporation and transpiration for wheat-only (control) and wheat under-sown with sub-clover at Burramine, Victoria, 2019

Note: The sub-clover was terminated on 25 September 2019

Error bars depict the standard error of the mean of three replicate plots.

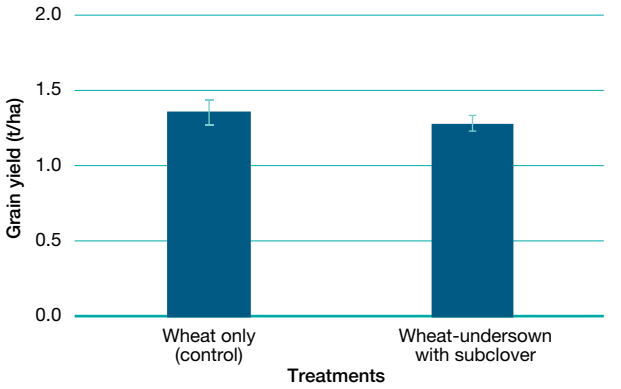


FIGURE 2 Grain yields for wheat only (control) and wheat under-sown with sub-clover at Burramine, Victoria, 2019
Error bars depict the standard error of the mean of three replicate plots.

Sub-clover seedlings growing in the seeding row, before being terminated on 25 September 2019.

Summer cover crop treatments

Summer cover crops emerged following rainfall during January 2020 and produced 0.6–0.7t/ha DM biomass before being sprayed out with glyphosate on 18 March 2020 (Figure 3).

Soil water was measured by soil coring at a depth of up to 1m when the winter crop (canola) was sown on 13 May, 2020. Compared with the fallow/control treatment, the medic and buckwheat summer cover crop (cover crop mix 1) depleted 6 per cent of soil moisture and the sorghum, millet, forage rape and tillage radish cover crop (cover crop mix 2) depleted 13 per cent of soil water (Figure 4a). The effect on total soil water was not statistically significant between these treatments.

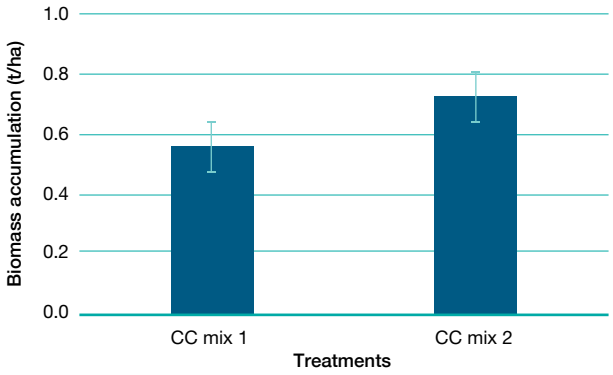
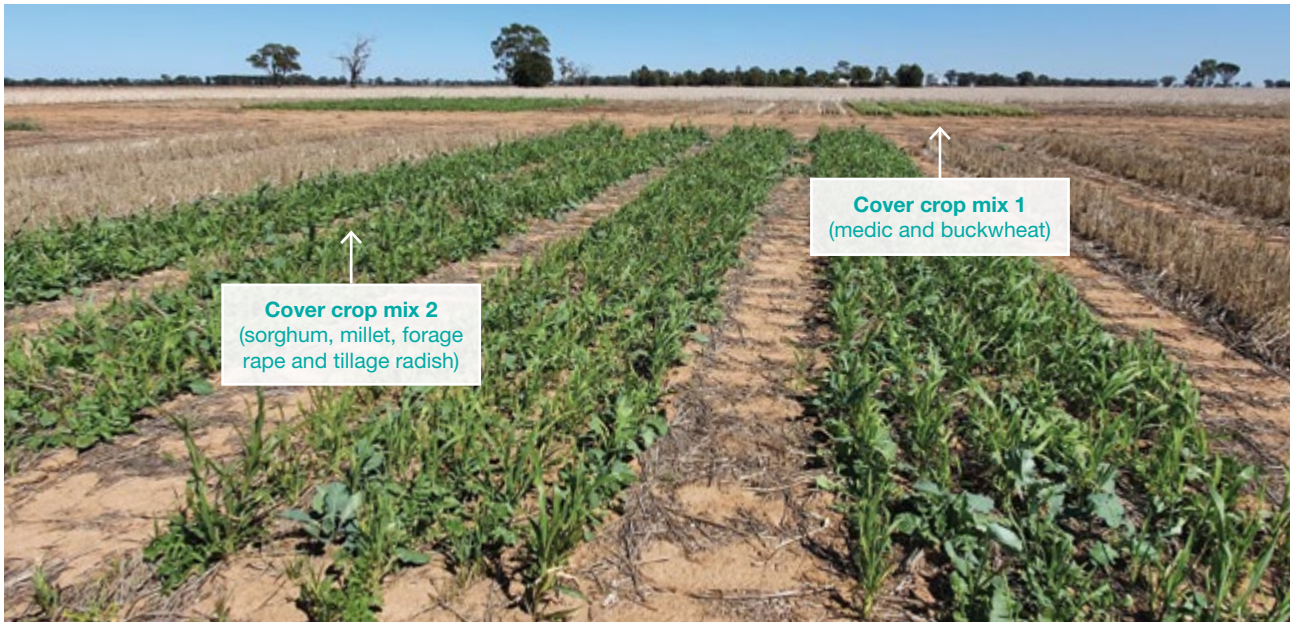


FIGURE 3 Biomass accumulation of summer cover crop treatments (CC mix 1: medic and buckwheat and CC mix 2: sorghum, millet, forage rape and tillage radish) after eight weeks of growth before being sprayed out with glyphosate on 16 March 2020 at Burramine, Victoria



Cover crop treatments prior to being sprayed out with glyphosate on 18 March 2020.

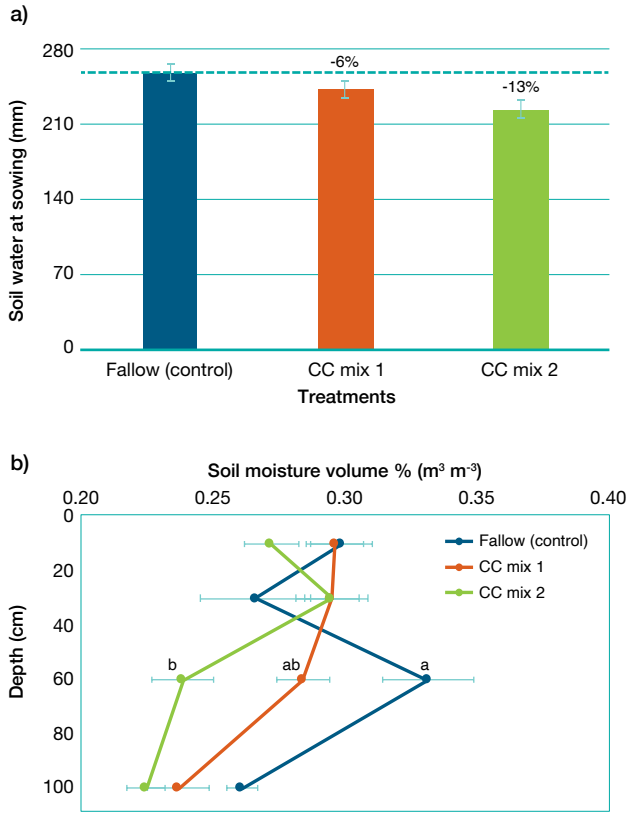


FIGURE 4 Effect of summer cover crop (cover crop mix 1: medic and buckwheat and cover crop mix 2: sorghum, millet, forage rape and tillage radish on total soil water (a) and soil water content up to 1m depth (b) at sowing of the winter canola crop, 13 May 2020 at Burramine, Victoria

When compared with the soil water content at different depths, cover crop mix 2 used significantly more soil water than the fallow (control), but only at 60cm depth (Figure 4b). The increase in soil water use at 60cm depth may be related to the rooting depth and rooting patterns of the different species in cover crop mix 2.

The full effect of the 2020 summer crop treatments on soil water and changes in soil biological function under the 2020 winter canola crop will be determined after the canola is harvested and yields are analysed.

Acknowledgements

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