# Companion cropping Wheat and Chickpea – Billa Billa.

By Andrew Erbacher, Research Agronomist with DAF and proud Queenslander.

## Research Question

What is the yield and economic impact of growing wheat and chickpea together as companion crops? Can this system improve ground cover and therefore fallow efficiency after chickpeas?

## Key Findings

1. Combined yields of companion crops were equivalent to those of monoculture crops.
2. Companion cropping Wheat with Chickpea has provided more stubble cover.
3.

## Background

Everyone knows that Queensland grows the best chickpeas, but chickpeas leave the soil quite bare. This bare soil then reduces our fallow efficiency (amount of fallow rainfall captured for use by the next crop), which is a big problem in an area that relies on stored soilwater for yield.

Our team recently completed a study growing cover crops in the fallow to improve ground cover and soilwater available to the next crop, so we understand the value of ground cover and when we saw the opportunity to try growing the cover crop with our chickpeas we were keen to give it a go.

Companion crops are not new or novel, they are in every home vege garden; from marigolds to keep the pests out of tomatoes, or flowers to attract pollinators into the pumpkin patch. What is novel is doing this on a broadacre scale and with mechanically harvested crops.

A review by CSIRO (Fletcher et al 2016) showed potential to increase crop productivity with intercrops; particularly with 'peaola' (canola and fieldpea), which increase productivity by 50% in 24 of 34 studies reviewed. They also found cereal-legume intercrops to increase productivity in 64% of studies.

That review focused on temperate cropping areas of southern Australian and internationally, so the question remains whether these systems will perform in a sub-tropical environment and a farming system reliant on stored soilwater for yield stability.

Given our reliance on stored soilwater for maintaining grain yield and the fallow efficiency cost of low stubble cover following chickpea; we focused our efforts on wheat and chickpea, with the research questions of: Can we increase stubble cover after chickpea? and What is the yield impact of growing wheat and chickpea together as companion crops?

## What was done

With our objective of increasing ground cover after chickpeas, we met with growers and agronomists at Goondiwindi to discuss how we were going to go about this. From this a treatment list was developed (Table 1), with the foreseen challenge of 'how are we going to grow these two crops so the more competitive (wheat) crop doesn't dominate too much?'. The group were also keen to look at the 'peaola' system, but we went with the Canadian version of linseed-chickpea would be better suited to our chickpea's June planting window.

*Table 1 Treatments applied at Billa Billa*

| | |
|---|---|
| 1. | Wheat (Control) |
| 2. | Chickpea (Control) |
| 3. | Chickpea followed by a cover crop |
| 4. | Chickpea/Wheat mixed, Sprayout Chickpea |
| 5. | Chickpea/Wheat mixed, Sprayout Wheat |
| 6. | Chickpea/Wheat, alternate rows |
| 7. | Chickpea/Wheat, Mixed within rows, 50:50 |
| 8. | Chickpea/Wheat, Mixed within rows, 67:33 |
| 9. | Linseed /Chickpea, alternate rows |
| 10. | Linseed (Control) |

This trial was planted at Billa Billa on 30 June using a twin-cone seven row plot planter; plumbed so one cone delivered to odd rows (1, 3, 5, 7) and the other to even rows (2, 4, 6). This allowed us to plant all treatments as a single pass operation.

Each species tested in companions, was grown as a monoculture at recommended planting rates as a base comparison. Varieties were also selected for suitability to a June planting date. Hellfire wheat was planted at 46 kg/ha for a target population of 1 million plants per hectare; Seamer chickpea was planted at 60 kg/ha for a target population of 250,000 plants per hectare; and Glenelg linseed was planted at 25 kg/ha.

The two "sprayout" treatments (trts 4 & 5) were planted at a full rate of each crop, so the harvested population was the same as the monocultures. These were planned to double plant so the crops were inter-row planted to each other, but with wet conditions at planting we opted to only traverse the paddock once and planted them mixed within the row.

The treatments were both crops were harvested had planting rates reduced to reflect a normal plant density; that is for alternate row treatments the in-row population was the same as the monoculture controls, and the 'mixed' treatments had 500,000 wheat plus 125,000 chickpea per hectare or 333,333 wheat plus 166,667 chickpea per hectare spread evenly across all seven rows.

The trial had insects monitored for each plot, but fungicides and insecticides were applied to the entire trial when commercial best practice would recommend treatment of any single treatment. As the season turned out, two fungicides were applied for Ascochyta management and one insecticide for helicoverpa.

In the spray-out treatments, MCPA plus Ally was applied to kill chickpea at flag leaf emergence, and verdict plus oil was applied to kill wheat at first flower of the chickpea. With our late June planting date, these both occurred together in early September.

Hand cuts were taken at physiological maturity, separating the crops within each treatment. These were subsequently threshed to measure a hand cut grain yield. The trial was also desiccated at this time to ensure even dry-down of the treatments, and the trial was harvested two weeks later.

At harvest, a test strip was used to determine the optimum header set-up for the five crop combinations (wheat, chickpea, linseed, wheat & chickpea, linseed & chickpea), and then these adjustments were made between harvesting each plot. The header samples were then cleaned post-harvest to separate the seed types, then were weighed individually.

The monoculture crops will have different yield potentials, so it would be expected that combined yields of companion crops will be between the two monoculture crops being compared. In that situation it would be difficult to assess whether a benefit/penalty was achieved, so the crop yields are converted to a percentage of the monoculture crop then they can be added together. This combined percentage is called Land Equivalent Ratio (LER). An LER of 100% (ie 60% + 40%) suggests the same grain yield would have been achieved by growing a paddock of each crop. An LER of 80% would mean there was antagonism between the crops resulting in a 20% reduction in yield, whereas our hope is to achieve an LER greater than 100%. For example 60% wheat plus 60% chickpea equals 120% LER, which would require 20% more land planted with monocultures to harvest the same amount of grain.

## Results

Our maturity biomass, hand cut grain yield and header yield all produced similar relative yields (LER) and proportions of crops' contribution to yield. As such only header yields are presented here (Table 2); additional data is included in Appendix.

Grain yields indicate the wheat had a competitive advantage over the chickpea. This was most evident in the mixed 50:50 and two "sprayout" treatments, where the wheat population established was high enough to limit the chickpea yield to ~10% of the monoculture chickpea (Table 2).

Wheat was sprayed out at first flower of the chickpea, which coincided with flag leaf of the wheat, so chickpea was sprayed out on the same date. It is interesting that spraying out the wheat or chickpea at this stage produced the same yield for the remaining crop as was achieved when both crops were harvested in "Chickpea/Wheat, Mixed 50:50". That said, a yield penalty is not unexpected in an environment where crops frequently rely on stored water to set grain.

The two treatments with wheat and chickpea mixed in the rows were approximately 100% LER. The 50:50 split treatment was slightly lower (93%) in the header harvested sample, but the hand cuts were 100% for both biomass and grain in that treatment.

Reducing the population of wheat relative to chickpea (67% chickpea: 33% wheat, based on best practice populations of 100 wheat plants/$m^2$ and 25 chickpea plants/$m^2$) lifted the yield of the chickpea to 30% of the monoculture chickpea, maintaining the 100% LER.

Separating the wheat and chickpea into an alternate row configuration had a similar impact on the chickpea yield, lifting from 10% up to 30% of the monoculture chickpea, but at the expense of wheat yield and LER. This reduction in wheat yield and LER was small (10%), but it was consistent for total biomass, hand cut yield and header yield.

*Table 2 Harvested grain yield of the crops grown at Goondiwindi in kg/ha and as percentage of the Monoculture Controls. Treatments with different letters are significantly different to other treatments in that crop only at p = 0.05. Analysis cannot be completed across crop type or for combined yields.*

| | Wheat | Chickpea | Linseed | Combined yield | |
|---|---|---|---|---|---|
| Control (Monoculture) | 2160a | 1496a | 778a | | |
| Chickpea followed by Cover crop | | 110%a | | | |
| Chickpea/Wheat, alternate rows | 56%b | 32%c | | 1693 | 88% |
| Chickpea/Wheat, Mixed within rows, 50:50 | 87%a | 7%d | | 1978 | 94% |
| Chickpea/Wheat, Mixed within rows, 67:33 | 70%b | 29%c | | 1943 | 99% |
| Chickpea/Wheat (mixed), Sprayout Chickpea | 87%a | | | 1888 | 87% |
| Chickpea/Wheat (mixed), Sprayout Wheat | | 11%d | | 170 | 11% |
| Linseed /Chickpea, alternate rows | | 62%b | 40%b | 1239 | 102% |
| *LSD* | *295.2 (13.7%)* | *213.5 (14.6%)* | *140.1 (18%)* | | |

## Implications for growers

With only one season's data we should be careful not to make strong conclusions, but this does show that it is possible to grow companion crops in Queensland on stored soilwater without a yield penalty. More work is needed manipulating crop configuration to get the best mix of crop type in the harvested sample and looking at different crop combinations.

The objective of growing the cereal with chickpea was to increase fallow efficiency after chickpea, increasing the yield potential of the next crop. Therefore, these sites have been maintained over the summer, cover crops have been grown after chickpea, and the sites will be soil sampled then planted to a common crop again this winter to measure any residual benefits (more water or nitrogen) achieved by having companion cropped last year.

## Reference

Fletcher AL, Kirkegaard JA, Peoples MB, Robertson MJ, Whish J & Swan AD 2016, 'Prospects to utilise intercrops and crop mixtures in mechanised, rain-fed, temperate cropping systems', Crop & Pasture Science, vol. 67, pp 1252-1267.

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## Trial details

Location: Billa Billa

Crop: Wheat, Chickpea, Linseed

Soil type: Duplex

In-crop rainfall:

Fertiliser: 25 kg/ha Granulock Z

# Appendix

*Table 3:* Above ground biomass of various companion crops and comparisons to the monoculture crop. Letters signify statistical differences within the crop type; treatments with similar letters are not significantly different at 5% confidence. Chickpea data was transformed to $\sqrt{x}$ for analysis, shown in brackets (x). LSD and letters relate to transformed means; back-transformed means are also presented. LSD (least significant difference) is how different values need to be to be considered statistically significant.

Land Equivalent Area (LER) is a means of comparing combined yields of companion crops of species different yield potentials; an LER of 100% represents the same yield as growing the crops in separate paddocks. Combined yield and LER were not analysed.

| | Wheat | | | Chickpea | | | Linseed | | | Combined yield | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Biomass (kg DM/ha) | | % of Monoculture | Biomass (kg DM/ha) | | % of Monoculture | Biomass (kg DM/ha) | | % of Monoculture | Biomass (kg DM/ha) | LER |
| Control (Monoculture) | 6037 | a | 100% | 3973 (63.03) | a | 100% | 3034 | a | 100% | | |
| Chickpea followed by Cover crop | | | | 3783 (61.51) | a | 95% | | | | 3783 | 95% |
| Chickpea/Wheat, alternate rows | 3641 | b | 60% | 1292 (35.95) | c | 33% | | | | 4933 | 93% |
| Chickpea/Wheat, Mixed within rows, 50:50 | 5380 | a | 89% | 327 (18.08) | d | 8% | | | | 5707 | 97% |
| Chickpea/Wheat, Mixed within rows, 67:33 | 3869 | b | 64% | 1210 (34.78) | c | 30% | | | | 5079 | 95% |
| Chickpea/Wheat (mixed), Sprayout Chickpea | 5611 | a | 93% | | | | | | | 5611 | 93% |
| Chickpea/Wheat (mixed), Sprayout Wheat | | | | 753 (27.44) | d | 19% | | | | 753 | 19% |
| Linseed /Chickpea, alternate rows | | | | 1672 (40.89) | b | 42% | 1454 | b | 48% | 3126 | 90% |
| *LSD* | *870.3* | | | *(8.116)* | | | *385.9* | | | | |

*Table 4:* Grain yield from biomass hand cuts of various companion crops and comparisons to the monoculture crop. Letters signify statistical differences within the crop type; treatments with similar letters are not significantly different at 5% confidence. Chickpea data was transformed to $\sqrt{x}$ for analysis, shown in brackets (x). LSD and letters relate to transformed means; back-transformed means are also presented. LSD (least significant difference) is how different values need to be to be considered statistically significant.

Land Equivalent Area (LER) is a means of comparing combined yields of companion crops of species different yield potentials; an LER of 100% represents the same yield as growing the crops in separate paddocks. Combined yield and LER were not analysed.

| | Wheat | | | Chickpea | | | Linseed | | | Combined yield | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grain Yield (kg/ha) | | % of Monoculture | Grain Yield (kg/ha) | | % of Monoculture | Grain Yield (kg/ha) | | % of Monoculture | Grain Yield (kg/ha) | LER |
| Control (Monoculture) | 2828 | a | 100% | 2209 (47) | a | 100% | 851.6 | a | 100% | | |
| Chickpea followed by Cover crop | | | | 2164 (46.5) | a | 98% | | | | 2164 | 98% |
| Chickpea/Wheat, alternate rows | 1654 | b | 58% | 656 (25.6) | b | 30% | | | | 2310 | 88% |
| Chickpea/Wheat, Mixed within rows, 50:50 | 2629 | a | 93% | 141 (11.9) | c | 6% | | | | 2770 | 99% |
| Chickpea/Wheat, Mixed within rows, 67:33 | 1904 | b | 67% | 664 (25.8) | b | 30% | | | | 2568 | 97% |
| Chickpea/Wheat (mixed), Sprayout Chickpea | 2618 | a | 93% | | | | | | | 2618 | 93% |
| Chickpea/Wheat (mixed), Sprayout Wheat | | | | 220 (14.8) | c | 10% | | | | 220 | 10% |
| Linseed /Chickpea, alternate rows | | | | 935 (30.6) | b | 42% | 330.9 | b | 39% | 1265 | 81% |
| *LSD* | *377.7* | | | *(6.435)* | | | *272.5* | | | | |

*Table 5:* Header grain yield of various companion crops and comparisons to the monoculture crop. Letters signify statistical differences within the crop type; treatments with similar letters are not significantly different at 5% confidence. LSD (least significant difference) is how different values need to be to be considered statistically significant.

Land Equivalent Area (LER) is a means of comparing combined yields of companion crops of species different yield potentials; an LER of 100% represents the same yield as growing the crops in separate paddocks. Combined yield and LER were not analysed.

| | Wheat | | | Chickpea | | | Linseed | | | Combined | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grain Yield (kg/ha) | | % of Monoculture | Grain Yield (kg/ha) | | % of Monoculture | Grain Yield (kg/ha) | | % of Monoculture | Grain Yield (kg/ha) | LER |
| Control (Monoculture) | 2160 | a | 100% | 1496.4 | a | 100% | 777.8 | a | 100% | | |
| Chickpea followed by Cover crop | | | | 1645.7 | a | 110% | | | | 1645.7 | 110% |
| Chickpea/Wheat, alternate rows | 1216 | b | 56% | 477.2 | c | 32% | | | | 1693.2 | 88% |
| Chickpea/Wheat, Mixed within rows, 50:50 | 1874 | a | 87% | 104.4 | d | 7% | | | | 1978.4 | 94% |
| Chickpea/Wheat, Mixed within rows, 67:33 | 1507 | b | 70% | 435.8 | c | 29% | | | | 1942.8 | 99% |
| Chickpea/Wheat (mixed), Sprayout Chickpea | 1888 | a | 87% | | | | | | | 1888 | 87% |
| Chickpea/Wheat (mixed), Sprayout Wheat | | | | 169.5 | d | 11% | | | | 169.5 | 11% |
| Linseed /Chickpea, alternate rows | | | | 925.4 | b | 62% | 313.5 | b | 40% | 1238.9 | 102% |
| *LSD* | *295.2* | | | *213.5* | | | *140.1* | | | | |

*Table 6*: Gross revenue generated from range of companion crops. These values are generated by attributing the 5 year commodity prices for Wheat ($360/t), Chickpea ($600/t) and Linseed ($1000/t) to the grain yields measured in either hand cuts or header harvest. This comparison does not account for differences in costs of growing the crops, or grading/post-harvest processing. Letters signify statistical differences within each yield assessment method; treatments with similar letters are not significantly different at 5% confidence. LSD (least significant difference) is how different values need to be to be considered statistically significant.

In both methods, Chickpea monoculture was the most profitable choice, while wheat and linseed monocultures were least profitable (in this site and season), except for "Wheat/Chickpea, Sprayout Wheat" in which the chickpeas were smothered by wheat which was then killed. All other companion crops returned revenues between the two monocultures (ie wheat and chickpea or linseed and chickpea), which is expected when companion crop yields are about 100% LER.

| **Treatment** | **Hand Cut ($/ha)** | | **Header ($/ha)** | |
|---|---|---|---|---|
| Wheat mono | 962 | bc | 735 | cd |
| Chickpea mono | 1575 | a | 1062 | ab |
| Linseed mono | 808 | c | 778 | cd |
| Chickpea f/b Cover crop | 1559 | a | 1168 | a |
| Chickpea/Wheat, alternate rows | 1039 | bc | 752 | cd |
| Chickpea/Wheat, Mixed within rows, 50:50 | 1003 | bc | 711 | cd |
| Chickpea/Wheat, Mixed within rows, 67:33 | 1139 | b | 822 | c |
| Chickpea/Wheat, Mixed, Sprayout Chickpea | 890 | bc | 642 | d |
| Chickpea/Wheat, Mixed, Sprayout Wheat | 177 | d | 120 | e |
| Linseed /Chickpea, alternate rows | 1023 | bc | 971 | b |
| *LSD* | *257* | | *142* | |