Crop competition effects on weeds and crops

Michael Widderick[1], Hanwen Wu[2], Asad Shabbir[3], Kerry Bell[1], Michael Walsh[4]

[1] Queensland Department of Agriculture and Fisheries, Toowoomba, QLD
[2] NSW Department of Primary Industries, Wagga Wagga, NSW
[3] NSW Department of Primary Industries, Orange, NSW
[4] University of Sydney, Camden, NSW

Key words

crop competition, weeds, row spacing, crop density, yield stability

GRDC code

US00084

Take home message

- There is convincing evidence that increased crop competition in sorghum, mungbean, faba bean and chickpea resulting from narrower row spacing and/or increased crop density reduces growth and seed production of feathertop Rhodes grass and sowthistle
- Importantly, in most instances, narrower row spacing and increased plant density did not have a negative impact on grain yield. In situations where resources (e.g. water) were not limiting, more competitive crops resulted in higher yield
- In general, when there is low yield potential (usually due to limited resources) growing a crop at a narrow row spacing or increased crop density is more likely to result in yield loss. In contrast, when there is a high yield potential, crops grown at wide row spacing are likely to result in yield loss when compared to narrow row spacing.

Background

In-crop weed control in the northern grain region (NGR) is heavily reliant on herbicides. However, this practice is not sustainable due to frequent and widespread herbicide resistance evolution. To prevent further resistance, and for herbicides to remain an important tactic for weed control, a combination of chemical and non-chemical weed control tactics is required.

An often overlooked weed management strategy is the use of competitive crops. Increased crop competition can be achieved by narrowing row spacing, increasing plant density or the use of more competitive crop species and cultivars. A competitive crop can compete against weeds to reduce weed growth (biomass) and seed production. However, a competitive crop will also need additional resources (water, nutrients) so that yield quantity and quality are not reduced.

Research was undertaken to quantify the effects of growing competitive summer (mungbean and sorghum) and winter (chickpea and faba bean) crops. This paper summarises research conducted at multiple sites over 6 years that focussed on the impact of row spacing, crop density and the combination of both on weed growth and seed production and crop yield.

Methodology

Over the 2016 to 2021 growing seasons, replicated field trials were established across the NGR at three locations (Narrabri, Wagga Wagga and Hermitage). The impact of crop row spacing, crop density and a combination of row spacing and crop density was measured on weed growth (biomass), weed seed production and crop yield.

Awnless barnyard grass (data not presented) and feathertop Rhodes grass (FTR) were established in summer crops and common sowthistle was established in winter crops. The weeds were established either with the crop by sowing weed seeds, or by transplanting weeds into the crop. Exact crop and weed densities were established in fixed quadrats from which weed and crop measurements were taken. To measure weed growth and seed production, destructive samples were taken. Crop yield was also measured in each trial. No herbicides were applied in the crops and background non-target weeds were manually removed.

For chickpea and faba bean, the row spacings compared were 23/25cm and 46/50cm (differences due to available planting equipment). For chickpea, the crop densities compared were 15 and 30 plants/m^2, and for faba bean 20 and 30 plants/m^2. For sorghum we compared the row spacings of 50 and 100cm and crop densities of 5 and 10 plants/m^2. For mungbean, row spacings of 25 and 50cm were compared and crop densities of 20, 30 and 35 plants/m^2.

The growing seasons during these studies ranged from severe drought to flooding. In drought seasons, supplementary irrigation was applied, but only to ensure crop and weed establishment and survival. In some cases, crop establishment and survival were greatly impacted by the season and any compromised data has been excluded from analyses.

The research produced a large quantity of data with a total of 49 winter and 19 summer crop trials. To establish key trends in data, a combined trial analysis across sites and seasons was undertaken. Separate analyses were done for each agronomic factor (i.e. row spacing, crop density and row spacing × crop density) and each crop. For these analyses, separate 'environments' were considered and compared. Within each trial, an environment was where both levels of the crop agronomy were present (e.g. if 25cm x 30 plants/m^2 is the crop agronomy being analysed and we have 4 different cultivars within the trial, this creates 4 different 'environments' within one trial). By pooling data in this way, we have been able to assess the impact of different agronomic factors (row spacing and/or crop density) over a range of different growing conditions.

Results

Faba bean

A more competitive faba bean crop, achieved through narrower row spacing (23/25cm) and/or increased crop density (30 plants/m^2), consistently reduced sowthistle growth (biomass) and seed production, while maintaining grain yields in most cases (Table 1).

Row spacing x crop density effect

The greatest impact was evident when faba bean was grown at a combined narrower row spacing and increased density where reductions in sowthistle growth and seed production were not only more frequent, but greater (Table 1).

Sowthistle biomass and seed production – Highly competitive faba bean, combining narrow row spacing (23/25cm) with high crop density (30 plants/m^2), resulted in a lower sowthistle biomass in 60% of environments (Table 1). Similarly, the seed production of sowthistle was reduced in a highly competitive faba bean crop in 53% of environments and the reduction ranged from 45 – 95%.

Faba bean yield – Growing faba bean at the highly competitive configuration either maintained or increased faba bean yield in 96% of environments (Table 1).

Table 1. Impacts of different agronomic factors (row spacing, crop density and row spacing × crop density) in faba bean on sowthistle biomass and seed production and faba bean yield. A Reduction or Increase denotes a statistically significant reduction or increase.

Agronomic factor	Sowthistle biomass	Sowthistle seed production	Faba bean yield
Narrow row spacing 25 vs. 50cm	Reduction in 44% of environments by 35 – 83%.	Reduction in 24% of environments by 36 – 71%.	Increase across all environments by 10%.
Increased crop density 20 vs. 30 plants/m^2	Reduction in 33% of environments by 37 – 74%.	Reduction in 23% of environments by 44 – 89%.	Increase across all environments by 7%.
Narrow row spacing × increased crop density 25cm × 30 plants/m^2 vs. 50cm × 20 plants/m^2	Reduction in 60% of environments by 47 – 87%.	Reduction in 53% of environments by 45 – 95%.	Increase at 25% of environments by 15 – 43%. No difference at 71% of environments Reduction at 4% of environments by 21%.

Chickpea

A more competitive chickpea crop, due to narrower row spacing (23/25cm) resulted in a reduction in sowthistle biomass but had no significant effect on sowthistle seed production (Table 2). Chickpea grain yields were either maintained or increased at this narrower row spacing. An increased chickpea density from 15 to 30 plants/m^2, resulted in a reduction in sowthistle growth (biomass) and seed production and an overall increase in chickpea yield across all environments.

Row spacing x crop density effect

When narrow row spacing and increased crop density were combined, sowthistle biomass and seed production were reduced to a greater degree than either alone, and yield was maintained in most cases.

Sowthistle biomass and seed production – Highly competitive chickpea grown at 23/25cm row spacing and density of 30 plants/m^2, reduced the biomass and seed production of common sowthistle in 44% and 30% of environments, respectively, compared to chickpea grown at the wider row spacing of 50cm and density of 15 plants/m^2 (Table 2). This is a lower percent of environments compared with faba bean (60% and 53%). Chickpea is known to be poorly competitive against weeds, and compared to the taller faba bean crop, this result is to be expected.

Chickpea yield – A competitive chickpea crop maintained grain yield in most environments (63%) and increased grain yield in 26% of environments (Table 2). In contrast, in only 11% of environments was there a decrease in crop yield in the highly competitive crop.

Table 2. Impacts of different agronomic factors (row spacing, crop density and row spacing × crop density) in chickpea on sowthistle biomass and seed production and sorghum yield. A Reduction or Increase denotes a statistically significant reduction or increase.

Agronomic factor	Sowthistle biomass	Sowthistle seed production	Chickpea yield
Narrow row spacing 25 vs. 50cm	Reduction across all environments by 8 – 55%.	No difference across environments.	No difference at 90% of environments. Increase at 10% of environments by 19 – 193%.
Increased crop density 15 vs. 30 plants/m^2	Reduction in 36% of environments by 37 – 74%.	Reduction in 27% of environments by 39 – 74%	Increase across all environments by 20%.
Narrow row spacing × increased crop density 25cm × 30 plants/m^2 vs. 50cm × 15 plants/m^2	Reduction in 44% of environments by 40 – 84%.	Reduction in 30% of environments by 39 – 85%.	No difference in 63% of environments. Increase in 26% of environments by 11 – 154%. Reduction in 11% of environments by 20 – 30%.

Sorghum

A more competitive sorghum crop, due to narrower row spacing (50cm) resulted in a reduction in FTR biomass and seed production (Table 3) and there was no difference in sorghum yield between row spacing treatments. An increased sorghum density from 5 to 10 plants/m^2, resulted in a reduction in FTR growth (biomass) and seed production and an overall increase in sorghum yield across all environments of 15%.

Row spacing x crop density effect

Feathertop Rhodes grass biomass and seed production – Highly competitive sorghum, combining narrow row spacing (50cm) with high crop density (10 plants/m^2), resulted in a lower FTR biomass in 35% of environments (Table 3) and the reduction ranged from 79 – 99%. The seed production of FTR was reduced in a highly competitive sorghum crop in 41% of environments (Table 3).

Sorghum yield – Growing sorghum at the highly competitive configuration either maintained or increased sorghum yield (Table 3). There were no reductions in yield across environments as a result of narrow row spacing and increased crop density.

Table 3. Impacts of different agronomic factors (row spacing, crop density and row spacing × crop density) in sorghum on feathertop Rhodes grass biomass (growth) and seed production and chickpea yield. A Reduction or Increase denotes a statistically significant reduction or increase.

Agronomic factor	FTR biomass	FTR seed production	Sorghum yield
Narrow row spacing 50 vs. 100cm	Reduction in 32% of environments by 61 – 99%.	Reduction in 32% of environments by 49 – 91%.	No effect. Yield maintained.
Increased crop density 5 vs. 10 plants/m^2	Reduction across all environments by 3 – 99%.	Reduction across all environments by 10 – 99%.	Increased across all environments by 15%.
Narrow row spacing × increased crop density 50 cm × 10 plants/m^2 vs. 100 cm x 5 plants/m^2	Reduction in 35% of environments by 79 – 99%.	Reduction in 41% of environments by 56 – 97%.	Increase in 38% of environments by 45 – 67%. No difference in 62% of environments.

Mungbean

A more competitive mungbean crop, due to narrower row spacing (25cm) resulted in a reduction in FTR biomass and seed production at all sites (Table 4). Yield was not different between row spacing treatments at most (80%) sites, however there was an increase in yield at 10% of sites and a reduction in yield, also at 10% of sites. An increased mungbean density from 20 to 30/35 plants/m^2, resulted in a reduction in FTR biomass and seed production across all sites, however the magnitude of reduction differed greatly from 9-98% (Table 4). An increased mungbean density had no impact on crop yield.

Row spacing x crop density effect

Feathertop Rhodes grass biomass and seed production – Highly competitive mungbean, combining narrow row spacing (25cm) with high crop density (30/35 plants/m^2), resulted in a lower FTR biomass and seed production across all environments (Table 4).

Mungbean yield – Growing mungbean at the highly competitive configuration increased mungbean yield in all environments, with the yield increase averaging 7% (Table 4).

Table 4. Impacts of different agronomic factors (row spacing, crop density and row spacing × crop density) in mungbean on feathertop Rhodes grass biomass (growth) and seed production and mungbean yield. A Reduction or Increase denotes a statistically significant reduction or increase.

Agronomic factor	FTR biomass	FTR seed production	Mungbean yield
Narrow row spacing 25 vs. 50cm	Reduction across all environments by 4 – 99%.	Reduction across all environments by 13 – 98%.	Increase in 10% of environments by 38 – 73%. No change at 80% of environments Reduction in 10% of environments by 40 – 55%.
Increased crop density 20 vs. 30 or 35 plants/m^2	Reduction across all environments by 9 – 88%.	Reduction across all environments by 11 – 98%.	No effect. Yield maintained.
Narrow row spacing × increased crop density 25 cm × 30/35 plants/m^2 vs. 50cm × 20 plants/m^2	Reduction across all environments, by 15 – 100%.	Reduction across all environments by 28 – 100%.	Increase across all environments by 7%.

Discussion

Growing a competitive crop at a narrow row spacing and/or increased crop density is likely to reduce in-crop growth (biomass) and seed production of weeds, and this has been demonstrated for sowthistle and FTR in chickpea and faba bean, and sorghum and mungbean, respectively. Reducing weed growth via a competitive crop takes the reliance off herbicides for in-crop weed control. A competitive crop will provide complimentary weed control to herbicide application by reducing the growth and seed production on any survivors, thus preventing weed spread and persistence. This is important for keeping weed densities low and also for preventing the spread of herbicide resistance.

Favourably, the more competitive crop configurations maintained crop yield in most environments, and in some environments resulted in significant yield gains. In a minority of environments, competitive crop configurations resulted in crop losses due to less favourable seasonal conditions. A more competitive crop will require more resources (e.g. water) in order to retain or increase crop yield and grain quality.

Impacts on crop yield

One of the key considerations for the adoption of growing a competitive crop via narrow row spacing and/or increased crop density is the impact on crop yield, especially in dry seasons or in low rainfall regions. In general, when there is low yield potential (usually due to limited resources), going to a narrow row spacing or increased crop density is more likely to result in yield loss. In contrast, when there is a high yield potential, crops grown at wide row spacing are likely to result in yield loss when compared to narrow row spacing.

A 3-year study undertaken by Kleemann and Gill (2010) investigated the effects of row spacing on growth and yield of wheat in South Australia. The study took place in three growing seasons with below average rainfall (286–361mm vs a long-term average of 434mm). Across the study, and despite the lower rainfall, there was a yield penalty for growing wheat at a wide row spacing compared to a narrow row spacing. Wheat yield declined by 5–8% as row spacing increased from 18 to 36cm and by a further 12–20% when row spacing increased from 36 to 54cm.

Modelling by Whish *et al.,* (2005) compared the production of sorghum at solid row configuration versus skip-row configuration using long-term weather records for a range of locations. They found that over the long-term, sorghum in a solid configuration produced a higher average yield.

In a comparison of 18 mungbean field trials from across NSW and Queensland, Moore and Dunn (2019) found a narrow row spacing of 25 – 40cm provided a significant grain yield advantage over a 100cm row spacing. Similarly, a publication by Gentry (2010) outlining the management of mungbeans, identifies that narrow row mungbean (15 – 40cm) have potential yield benefit as yield potential increases above 1 t/ha and that the yield margin increases to 10–15% in favour of narrow rows as yield potential approaches 2 t/ha. However, under severe moisture stress, the combination of wide rows and heavy stubble cover often results in a better yield than narrow rows.

To spread yield loss uncertainty, grow competitive crops when resources are likely to be plentiful or only in select paddocks rather than the whole property. A competitive crop may be used as a replacement for in-crop herbicides if weed densities are low, or in a situation of high weed density, combining a competitive crop with pre- and post-emergence herbicide will minimise weed survival and seed production.

References

Gentry J (2010). Mungbean Management Guide 2nd Edition. Available online: https://era.daf.qld.gov.au/id/eprint/7070/1/mung-manual2010-LR.pdf .

Kleemann S and Gill G (2010) Influence of row spacing on water use and yield of rain-fed wheat (*Triticum aestivum* L.) in a no-till system with stubble retention. Crop and Pasture Science 61, 892-898.

Moore N and Dunn M (2019) Mungbean and soybean agronomy - time of sowing, row spacing and plant population: findings from combined trial analysis 2013-2018. GRDC Update Paper https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2019/08/mungbean-and-soybean-agronomy-time-of-sowing,-row-spacing-and-plant-population-findings-from-combined-trial-analysis-2013-2018

Whish J, Butler G, Castor M, Cawthray S, Broad I, Carberry P, Hammer G, McLean G, Routley R and Yeates S (2005) Modelling the effects of row configuration on sorghum yield reliability in north-eastern Australia. Australian Journal of Agricultural Research 56, 11-23.

Additional/useful resources

Crop placement and row spacing fact sheet northern region. Available online: https://grdc.com.au/__data/assets/pdf_file/0018/210294/crop-placement-and-row-spacing-northern-fact-sheet.pdf.pdf

DAF Queensland Grains Research – 2016. Available online: https://www.publications.qld.gov.au/dataset/a103b315-253d-42ab-9a39-0051b1ed9739/resource/f564d65c-3bb8-425f-aabc-c0574243ca82/download/rantrials2016-24julylr.pdf

DAF Queensland Grains Research – 2017-18. Available online: https://www.publications.qld.gov.au/dataset/a103b315-253d-42ab-9a39-0051b1ed9739/resource/f4e08873-52bc-42c3-b81c-ec210646fef3/download/queensland-grains-research-1718-regional-agronomy.pdf

Acknowledgements

The research undertaken as part of this project is made possible by the significant contributions of growers through both trial cooperation and the support of the GRDC, the author would like to thank them for their continued support.

Contact details

Michael Widderick (Principal Research Scientist)
Queensland Department of Agriculture and Fisheries
Leslie Research Facility, Toowoomba
Ph: 07 4529 1325
Email: Michael.widderick@daf.qld.gov.au

Date published

March 2024