USING CROP COMPETITION TO SUPPRESS WEEDS

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COVER: Common sow thistle in a faba bean crop.
PHOTO: Queensland Department of Primary Industries

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Photo: Nicole Baxter

Weed management in the northern grain region

The northern grain region encompasses the grain growing regions of Queensland and New South Wales, where both summer and winter grain crops can be grown. Effective weed control is necessary to reduce the costly impacts of weeds on yield and grain quality.

Herbicides are an important weed control tactic for pre-plant and in-crop weed control. However, due to a longstanding dependence on these chemicals, there is now widespread herbicide resistance in weed populations infesting northern cropping systems.

In addition, there are limited selective herbicide options available for many crop:weed scenarios, such as controlling grass weeds in cereal crops (for example, feathertop Rhodes grass (FTR) in sorghum) and broadleaf weeds in pulse and oilseed crops (for example, common sow thistle in chickpeas).

To better control weeds and retain the usefulness of important herbicides, additional weed control practices need to be included in well-planned and integrated weed management programs.

An often-overlooked weed management tactic is the use of competitive crops to suppress in-crop weeds. Increased crop competition can be achieved by narrowing row spacing, increasing crop density and/or the use of more competitive crop species and cultivars.

Feathertop Rhodes grass in sorghum. Photo: QDPI

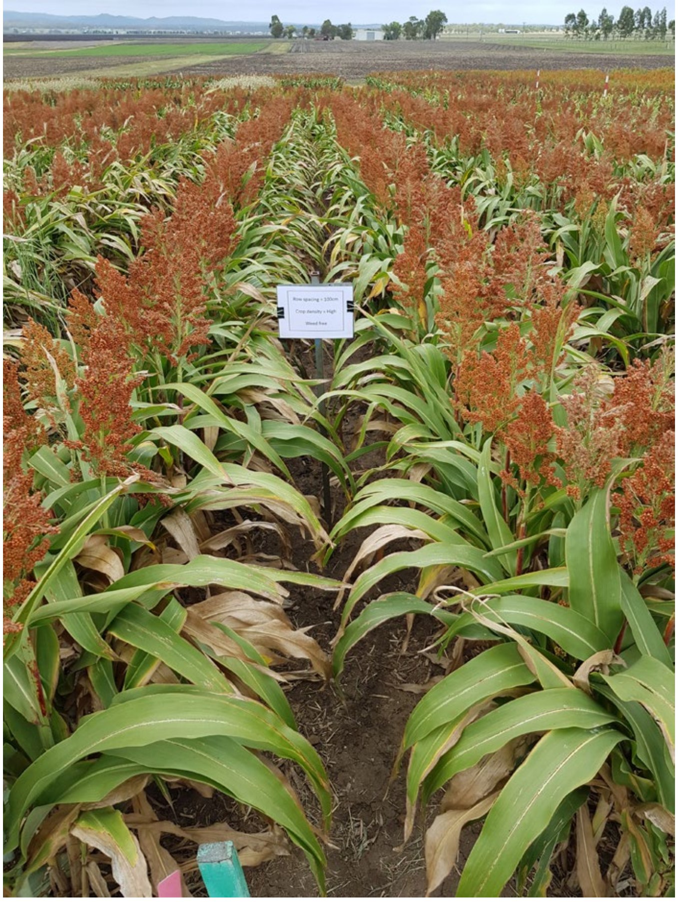
How does a competitive crop work?

Weeds compete with crops for the essential resources of water, light, nutrients and space. As a result, weeds can greatly reduce grain yield and quality. However, when a crop is given a competitive advantage, the weed growth (biomass) and seed production can be suppressed. In a resource-rich environment (that is, one not limited in water, nutrients, sunlight and space), a more competitive crop can also produce increased grain yields.

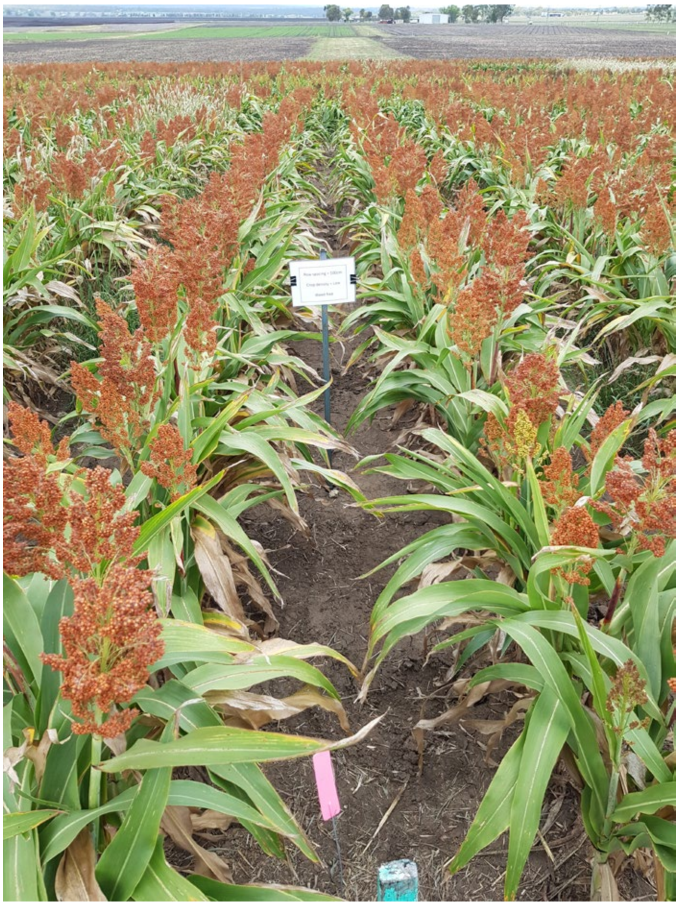
Modelling by Whish et al. (2005) compared the production of sorghum on solid-row configuration versus skip-row configuration using long-term weather records for a range of locations. They found that over the long term, sorghum in a solid configuration produced a higher average yield.

In a comparison of 18 mungbean field trials across NSW and Queensland, Moore and Dunn (2019) found that a narrow row spacing of 25 to 40 centimetres provided a significant grain yield advantage compared to a 100cm row spacing. Similarly, a publication by Gentry (2010) outlining the management of mungbeans, identified that growing mungbeans in narrow rows (15 to 40cm) had a probable yield benefit as yield potential increased above one tonne/hectare. The yield margin increased to 10 to 15 per cent in favour of narrow rows as yield potential approached 2t/ha.

Growing a competitive crop can also play a role in reducing the development of herbicide resistance. By reducing the reliance on herbicides for in-crop weed control and by suppressing weed seed production on weeds that have survived a herbicide, the development and spread of herbicide resistance can be slowed.



Sorghum at 100cm row spacing and 10 plants/m². Photo: QDPI



Sorghum at 100cm row spacing and five plants/m². Photo: QDPI

What was done

To gain a better understanding of crop competition and its place in northern region cropping systems, replicated field trials were established over the 2016 to 2021 growing seasons at four locations (Narrabri and Wagga Wagga in NSW, Hermitage and Kingaroy in Queensland). This publication highlights the findings of this research and implications for weed management.

The field trials focused on the pulse crops (chickpeas, faba beans and mungbeans) and on sorghum, as there was limited information on weed competition potential. Pulse crops, in particular, were considered to be poor competitors. The experiments therefore assessed the impact of crop row spacing and crop density on weed growth (biomass), weed seed production and crop grain yield.

The trials included common and troublesome weeds: awnless barnyard grass (ABG) and FTR in summer crops of mungbeans and sorghum; and common sow thistle in winter crops of chickpeas and faba beans. Weeds were established either with the crop by sowing seeds, or by transplanting. Destructive assessments were taken to measure weed growth, seed production and crop grain yield. No herbicides were applied in the crops and non-target weeds were manually removed.

For chickpeas and faba beans, the row spacings compared were 23/25cm and 46/50cm (differences were due to available planting equipment). For chickpeas, the crop densities compared were 15 and 30 plants per square metre, and for faba beans 20 and 30 plants/m². Sorghum was compared at row spacings of 50cm and 100cm and crop densities of 5 and 10 plants/m². For mungbeans, row spacings of 25cm and 50cm were compared and crop densities of 20, 30 and 35 plants/m².

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.

The research produced considerable data with a total of 49 winter and 19 summer crop trials. To establish key trends in the data, a combined analysis across environments and seasons was undertaken. Separate analyses were performed for each combination of agronomic factor (that is, row spacing, crop density and row spacing × crop density), weed species and crop. Separate environments were defined within a trial through the pairing of the same conditions (for example, cultivar, weed density) with both low and high levels of the agronomic factor.

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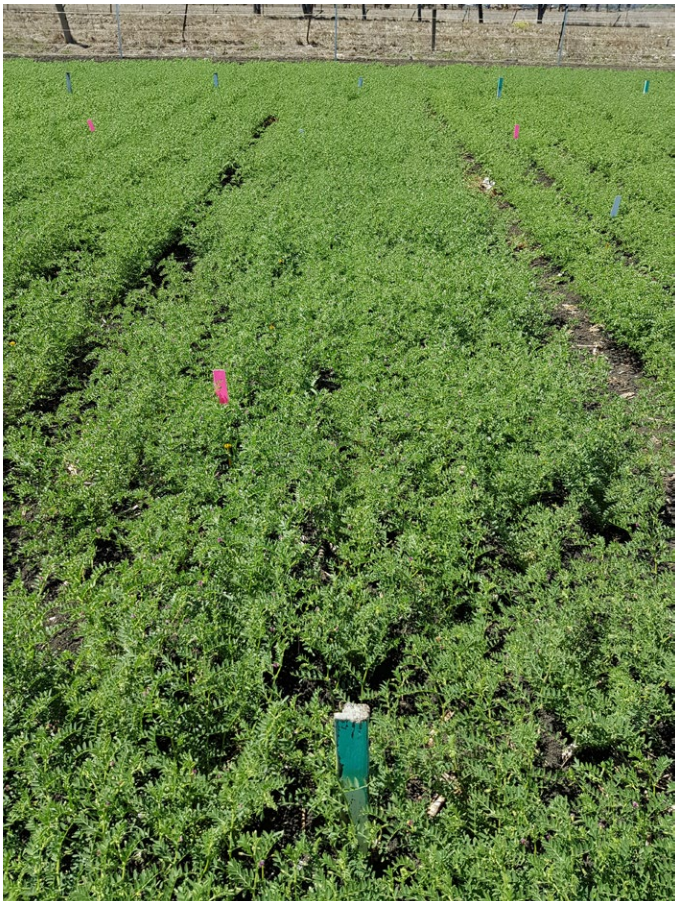


Chickpeas at 25cm row spacing. Photo: QDPI

Chickpeas at 50cm row spacing. Photo: QDPI

Faba beans at 25cm row spacing. Photo: QDPI

Faba beans at 50cm row spacing. Photo: QDPI

Sorghum

Sorghum is commonly grown with a row spacing of 100cm and in single or double skip-row configurations. This wide row spacing allows growers to optimise water use efficiency and enhance sorghum's resilience to varying conditions. However, growing sorghum on a wide row spacing provides little competition against in-crop weeds.

Row spacing effect

By growing sorghum on a narrow row spacing of 50cm, ABG biomass (an indicator of weed growth) and weed seed production were reduced at 35 per cent and 26 per cent, respectively, of environments covered by the trials. The magnitude of biomass reduction ranged from an average of 50 to 100 per cent with seed production reduced by an average of 68 to 99 per cent (Figure 1).

The result for FTR was similar where biomass and seed production were both significantly reduced in 32 per cent of environments (Figure 2). In these environments, the reduction in biomass ranged from an average of 61 to 99 per cent and the reduction in seed production from 49 to 91 per cent.

A site-specific example of reduction in weed seed production due to a narrower row spacing is provided in Figure 3.

Growing sorghum with a narrow row spacing had no effect on sorghum yield.

Sorghum density effect

An increase in sorghum density had a more consistent effect on reducing weed growth than decreasing row spacing.

For ABG, biomass and seed production were reduced across environments by increasing sorghum crop density from 5 to 10 plants/m^2 (Figure 1).

A site-specific example of the reduction in biomass is provided in Figure 4. This was also the case for FTR (Figure 2). An average reduction in seed production of ABG of 5495 seeds/m^2 and 30,132 seeds/m^2 for FTR is likely to have a major impact on reducing weed pressure and weed control inputs in subsequent crops.

Growing sorghum at an increased crop density delivered grain yield gains across environments when FTR was present (Figure 2). However, when ABG was present, significant yield gains were present in only 18 per cent of the environments. In 3 per cent of environments (one environment), there was a yield reduction of 57 per cent (Figure 1).

Combined row spacing and density effect

By combining a narrow row spacing of 50cm with an increased sorghum density of 10 plants/m^2, ABG biomass was reduced in 44 per cent of environments and the magnitude of reduction ranged from an average of 61 to 97 per cent.

Weed seed production was reduced in all environments by an average of 15,434 seeds/m^2 (Figure 1). This was almost three times the magnitude of reduction compared with growing sorghum with only an increased crop density. The effect on FTR was similar with a reduction in growth (biomass) in 35 per cent of environments and a reduction in seed production in 41 per cent of environments. The magnitude of reduction was large with an average 79 to 99 per cent reduction in biomass and 56 to 97 per cent reduction in weed seeds. Figure 5 shows the consistency in reducing FTR seed in a highly competitive sorghum crop across environments. A site-specific example is provided in Figure 6.

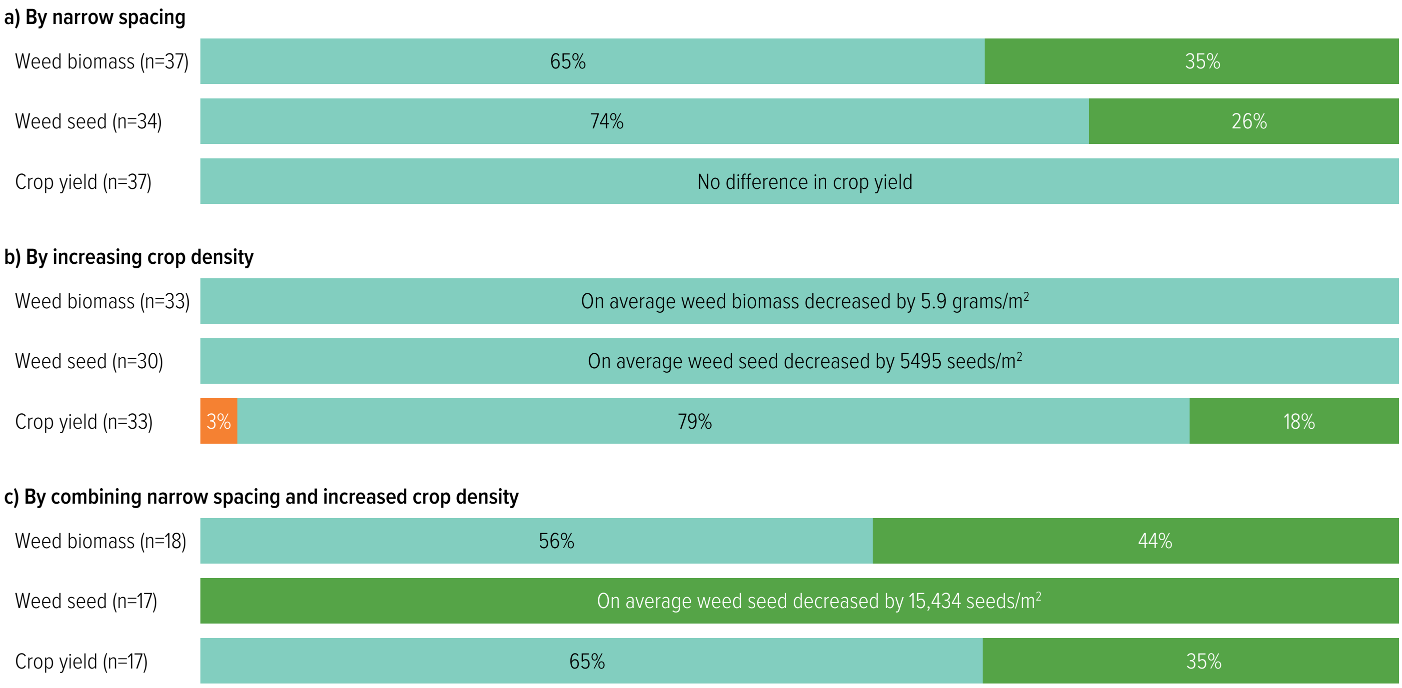
Combining a narrow sorghum row spacing and increased crop density did not result in any grain yield loss in any environments.

When ABG and FTR were present, there was a greater sorghum yield in 35 per cent and 38 per cent of environments respectively.

Figure 7 shows the trends in sorghum yield across environments for FTR and highlights that the overall trend was for an increased sorghum yield at a more competitive sorghum planting. Note: the rainfall received in February 2021 during flowering and grain fill was 60 per cent less than the monthly average for this site. The slight reduction in yield may be due to limited moisture at the high-competition treatment.

Suppression of awnless barnyard grass in sorghum

Figure 1: Sorghum crop competition effects on awnless barnyard grass (ABG) growth and seed production across environments and sorghum yield where a) a reduction in row spacing to 50cm was compared to a row spacing of 100cm, b) an increased sorghum density of 10 plants/m² was compared with 5 plants/m², and c) a more competitive sorghum crop planted at a narrow row spacing of 50cm and an increased density of 10 plants/m² was compared with sorghum planted at 100cm row spacing and 5 plants/m².

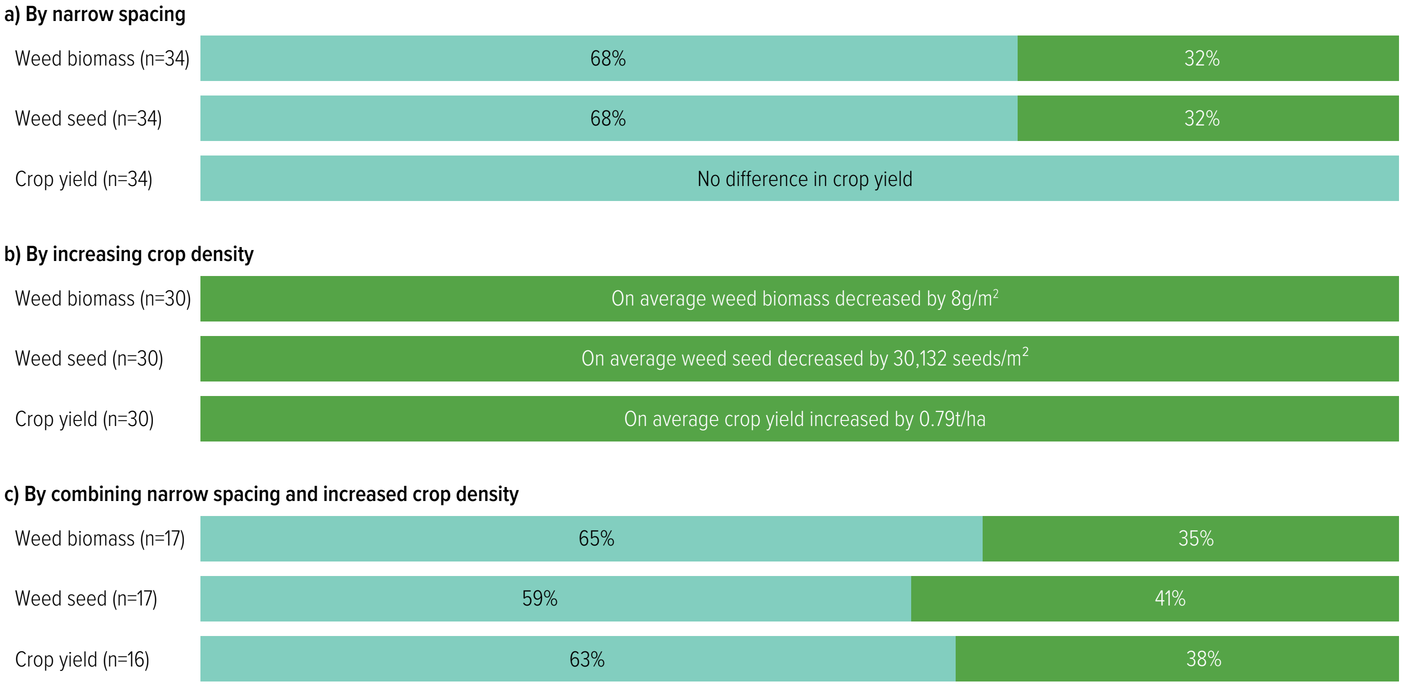


■ = a positive effect of either a decrease in weed growth (biomass) or seed production, or a gain in grain yield. ■ = no significant difference. ■ = a negative effect of either an increase in weed growth (biomass) or seed production, or a loss in grain yield. n = the number of environments and the per cent value in the bars is the per cent of environments where the result was observed. Where a bar is split into two or three colours, this indicates there was an interaction with the environment, whereas a single-coloured bar indicates a consistent main effect of the variables. Note: 'increases' or 'decreases' refers to significant increases or decreases, and 'no difference' or 'no effect' refers to no significant difference (at five per cent level of significance). Also, some rounded per cents will not add to 100 per cent due to the rounding process.

Source: QDPI

Suppression of feathertop Rhodes grass in sorghum

Figure 2: Sorghum crop competition effects on feathertop Rhodes grass (FTR) growth and seed production across environments and sorghum yield where a) a reduction in row spacing to 50cm was compared to a row spacing of 100cm, b) an increased sorghum density of 10 plants/m² was compared with 5 plants/m², and c) a more competitive sorghum planted at a narrow row spacing of 50cm and an increased density of 10 plants/m² was compared with sorghum planted at 100cm row spacing and 5 plants/m².



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Source: QDPI

Figure 3: a) Awnless barnyard grass (ABG) seed production/plant and b) feathertop Rhodes grass (FTR) seed production/plant as affected by sorghum row spacing (cm) at Hermitage, Queensland 2018-19. Within each graph, bars with no letters in common are significantly different at P = 0.05. Data has been back-transformed. Least significant difference of transformed data = 20.81 for ABG and 21.74 for FTR.

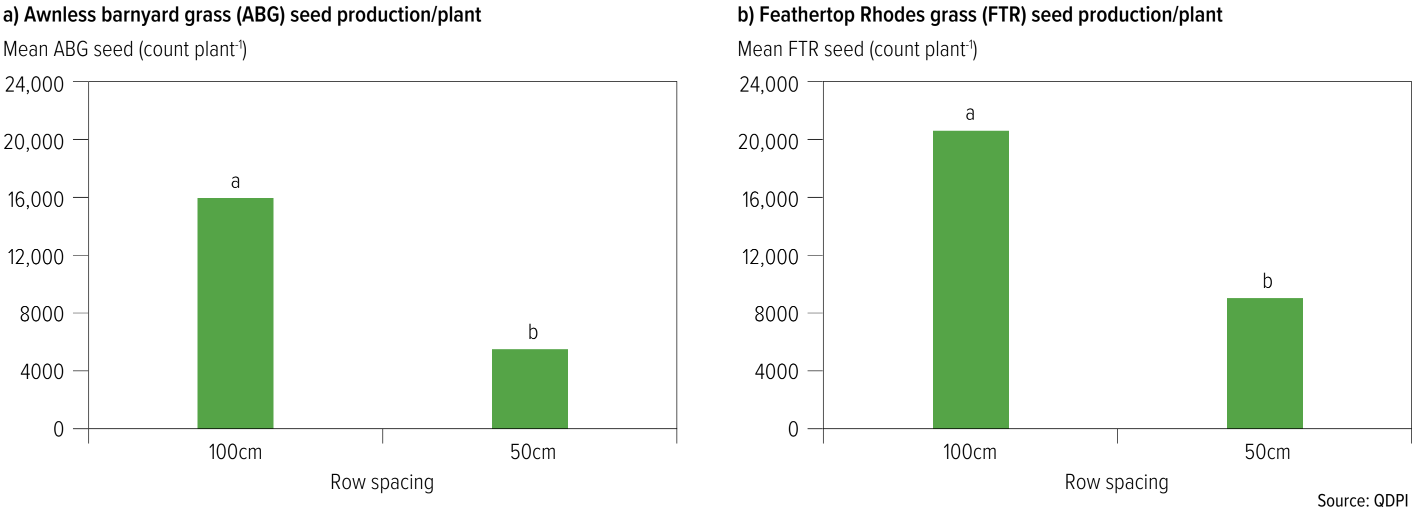


Figure 4: Effect of sorghum density (plants/m^2) on dry weight (DW) biomass of awnless barnyard grass (ABG), Narrabri, NSW, 2019. Bars with no letters in common are significantly different at P = 0.05. Data are back-transformed.

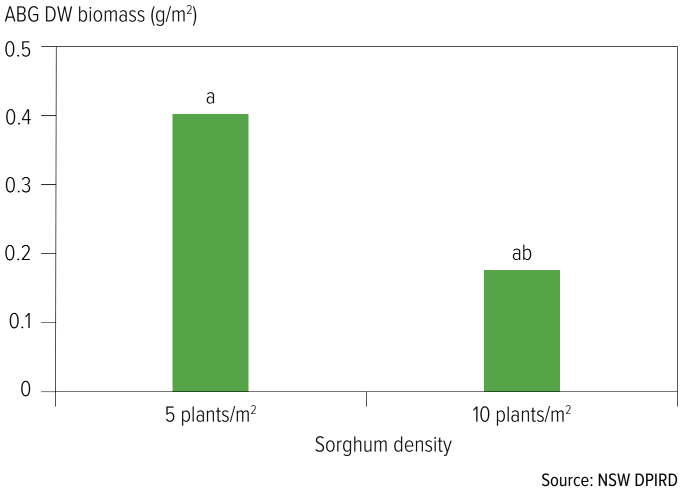
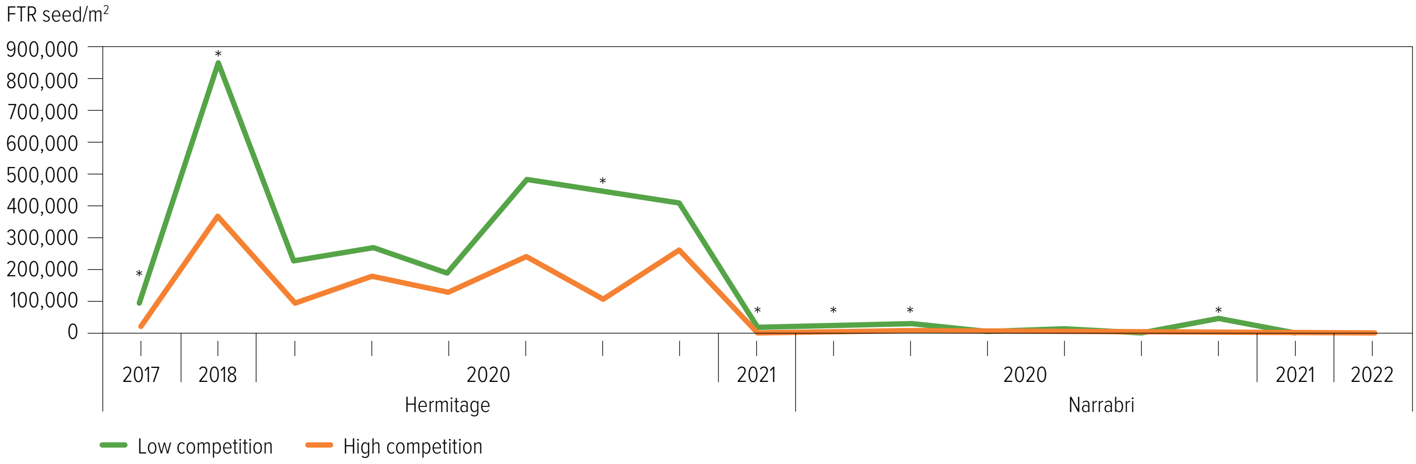
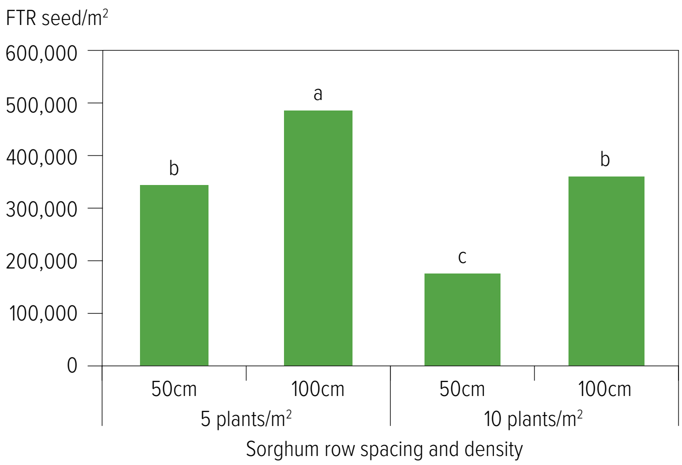


Figure 5: Sorghum crop competition effects on feathertop Rhodes grass (FTR) seed production. Where low competition = 100cm row spacing and 5 plants/m^2 and high competition = 50cm row spacing and 10 plants/m^2. * = a significant difference. Each vertical line on the x-axis denotes an environment, defined within a trial through the pairing of the same conditions (for example, cultivar, weed density) with both low and high levels of the agronomic factor.



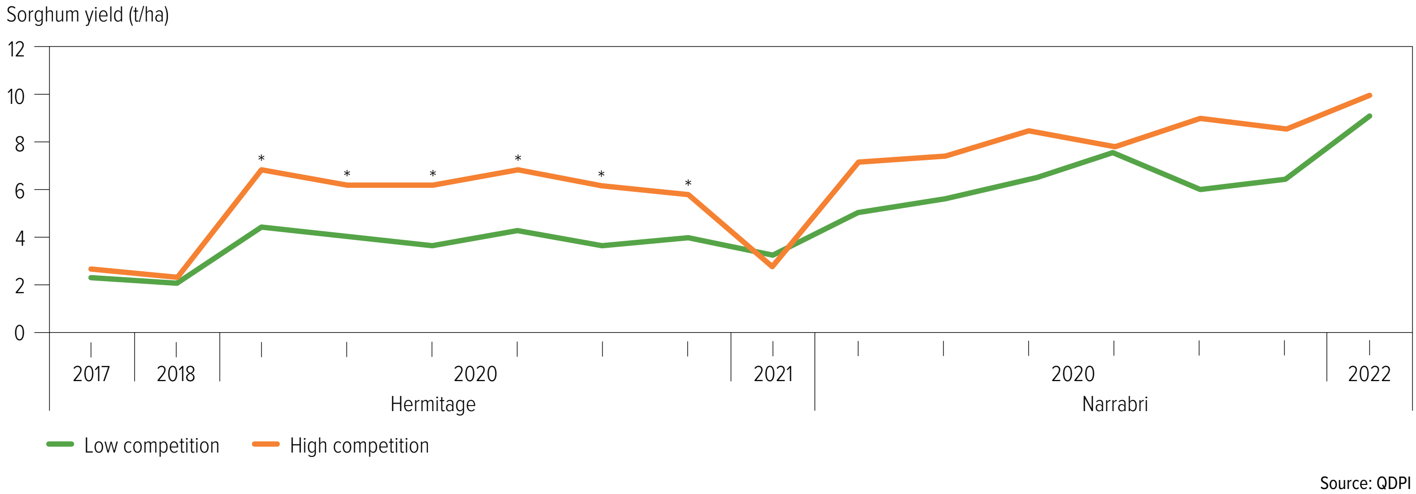
Source: QDPI

Figure 6: Influence of sorghum row spacing and density on feathertop Rhodes grass (FTR) seed production at Kingaroy, Queensland, 2019-20. Bars with no letters in common are significantly different at P = 0.05. Data are back-transformed.



Source: QDPI

Figure 7: Sorghum crop competition effects on sorghum grain yield. Where low competition = 100cm row spacing and 5 plants/m² and high competition = 50cm row spacing and 10 plants/m². * = a significant difference. Each vertical line on the x-axis denotes an environment, defined within a trial through the pairing of the same conditions (for example, cultivar, weed density) with both low and high levels of the agronomic factor.



Mungbeans

Mungbeans can be grown at a wide range of row spacings from 18 to 100cm. However, a row spacing of between 50cm and 100cm is most common. A crop density of 20 to 30 plants/m^2 is common in dryland situations and 30 to 40 plants/m^2 under irrigation.

Row spacing effect

A reduction in row spacing from 50cm to 25cm resulted in reduced ABG biomass in 22 per cent of environments (Figure 8).

This reduction ranged from an average of 29 to 99 per cent. There was one environment with a greater biomass at a narrow row spacing than at the wider row spacing. Across all environments, a narrow row spacing resulted in reduced ABG seed production and this averaged 4150 seeds/m^2. A site-specific example of the effect of a narrow row spacing on ABG seed production and biomass is shown in Figure 9.

A narrow mungbean row spacing reduced the growth and seed production of FTR across all environments (Figure 10). This reduction averaged 4743g/m^2 and 14,313 seeds/m^2 respectively; however, the magnitude of reduction varied greatly across environments with an average range of 4 to 99 per cent and 13 to 98 per cent.

A narrow mungbean row spacing provided a favourable grain yield gain in 16 and 10 per cent of environments when ABG and FTR respectively were present (Figures 8 and 10). The magnitude of yield increase ranged from an average 18 to 73 per cent. However, there was also a yield loss in the same proportion of environments with the magnitude of loss ranging from 37 to 60 per cent. The yield at the remaining environments did not differ.

Mungbean density effect

A greater crop density of 30 to 35 plants/m^2 compared to 20 plants/m^2 was effective in reducing the growth and seed production of FTR (Figure 10). A reduction in both the growth and seed production was measured across all environments with an average reduction of 25g/m^2 and 15,856 seeds/m^2.

The response of ABG to an increase in mungbean density varied with a reduction in weed biomass in 18 per cent of environments, with the magnitude of reduction ranging from an average 33 to 99 per cent, and an increase in 3 per cent of environments (one environment). However, across environments, there was a decrease in weed seed production with an average reduction of 3714 seeds/m^2 (Figure 8).

In most environments, the higher mungbean density had no negative effect on grain yield. This was the case across environments when FTR was present. When ABG was present, there was no difference in 91 per cent of environments. In 6 per cent of environments, there was an increase in yield.

The magnitude of yield increase ranged from an average 32 to 51 per cent. There was a negative yield reduction at one environment and this reduction was 21 per cent.

Combined row spacing and density effect

When a more competitive mungbean crop was grown at a narrow row spacing of 25cm and a crop density of 30 or 35 plants/m^2, there was a reduction in biomass and seed production for both ABG and FTR across all environments (Figures 8 and 10).

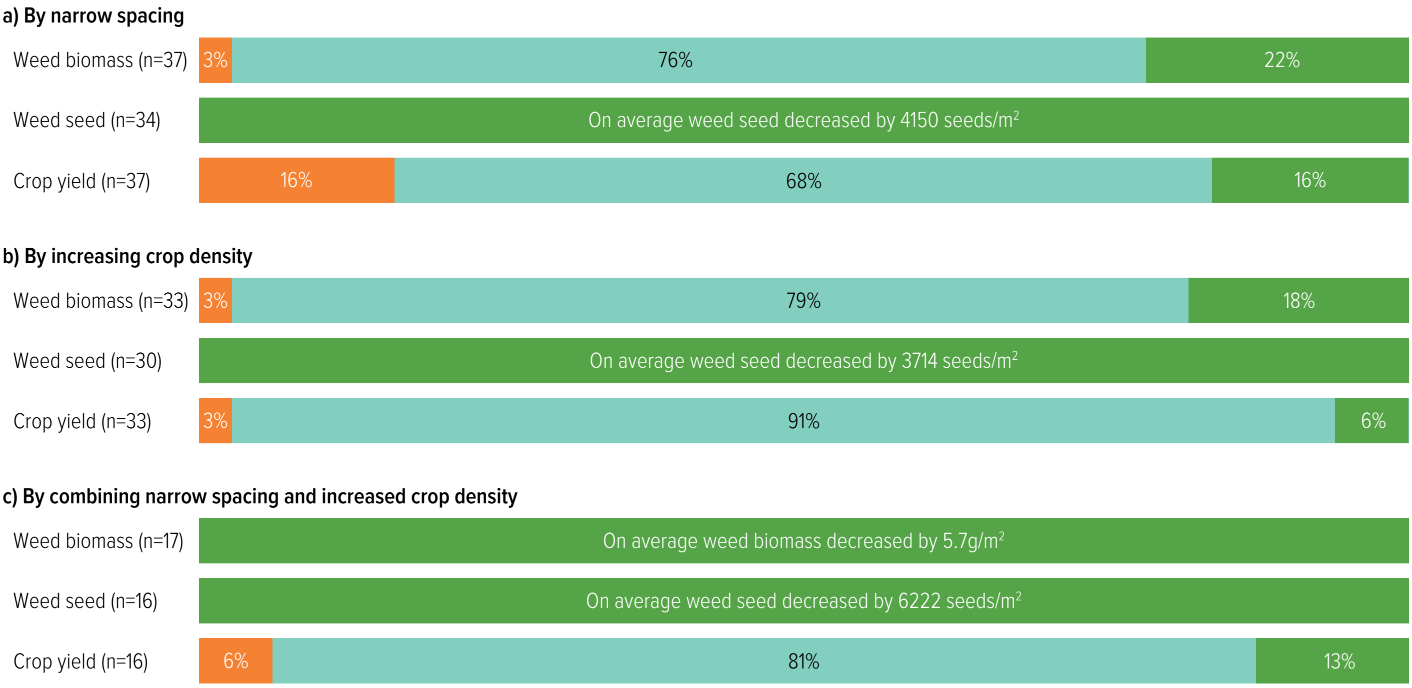
Favourably the grain yield of mungbeans was also greatest across all environments when FTR was present with an average increase in yield of 0.15t/ha.

When ABG was present, the yield was no different between the high and low competition scenarios in 81 per cent of the environments and there was an increase in yield at 13 per cent of the environments.

The magnitude of this increase ranged from an average 20 to 21 per cent. However, there was also a decrease in mungbean yield at 6 per cent of the environments with the magnitude of yield loss averaging 40 per cent.

Suppression of awnless barnyard grass in mungbeans

Figure 8: Mungbean crop competition effects on awnless barnyard grass (ABG) growth and seed production across environments and mungbean yield where a) a reduction in row spacing to 25cm was compared to a row spacing of 50cm, b) an increased mungbean density of 30 to 35 plants/m² was compared with 20 plants/m², and c) a more competitive mungbean crop planted at a narrow row spacing of 25cm and an increased density of 30 plants/m² was compared with mungbeans planted at 50cm row spacing and 20 plants/m².



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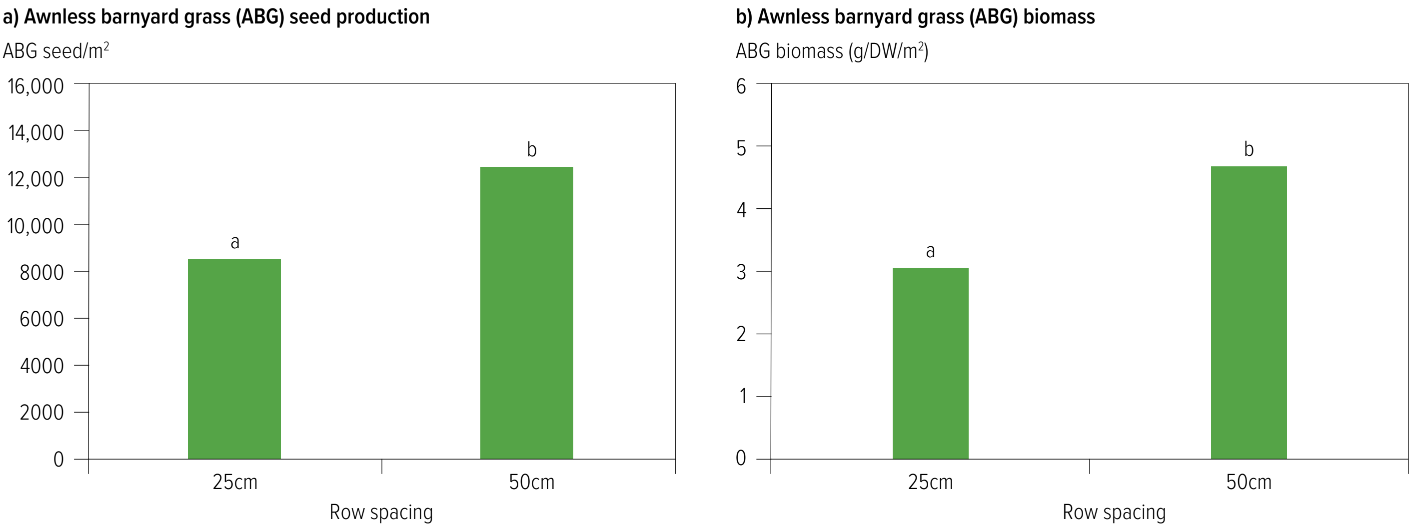
Source: QDPI

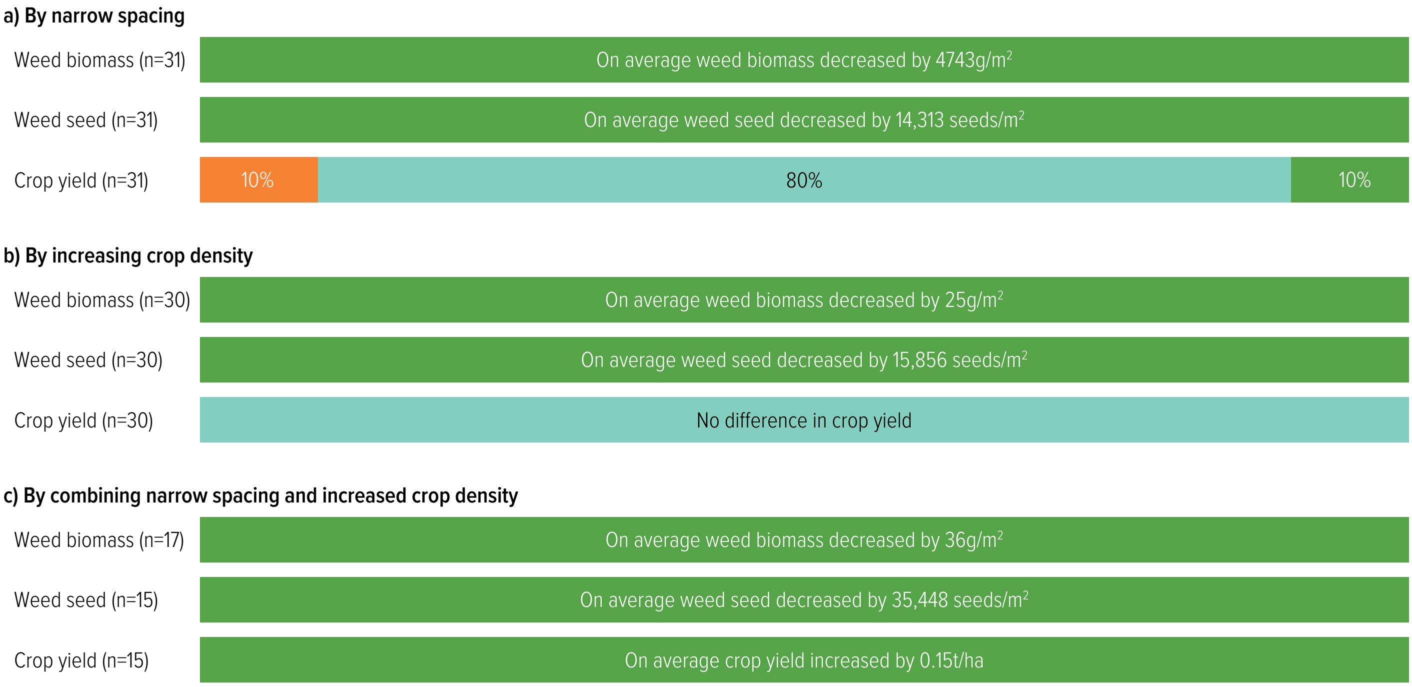
Figure 9: Effect of mungbean row spacing on ABG a) seed production and b) biomass, Kingaroy, Queensland, 2019-20. Within each graph, bars with no letters in common are significantly different at P = 0.05. Data are back-transformed.



Source: QDPI

Suppression of feathertop Rhodes grass in mungbeans

Figure 10: Mungbean crop competition effects on feathertop Rhodes grass (FTR) growth and seed production across environments and mungbean yield where a) a reduction in row spacing to 25cm was compared to a row spacing of 50cm, b) an increased mungbean density of 30 to 35 plants/m² was compared with 20 plants/m², and c) a more competitive mungbean planted at a narrow row spacing of 25cm and an increased density of 30 plants/m² was compared with mungbeans planted at 50cm row spacing and 20 plants/m².



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Source: QDPI

Chickpeas

Chickpeas have long been recognised as a poor competitor; however, this research shows that competitive gains can be made by narrowing row spacing and increasing crop density.

In the northern region, chickpeas can be grown at a wide range of row spacings from 18cm to 100cm. Crop density ranges from 20 to 40 plants/m^2 with a density of 30 plants/m^2 suggested to optimise yields.

Row spacing effect

By narrowing the chickpea row spacing from 50cm to 25cm, there was a reduction in common sow thistle biomass across environments, with an average decrease of 9.5g/m^2 (Figure 11).

However, this reduction in biomass did not result in any difference in common sow thistle seed production, which was the same at either row spacing.

A narrow row spacing saw an increase in chickpea grain yield in 10 per cent of environments; the average magnitude of this increase ranged from 19 to 193 per cent.

In the remainder of environments, there was no difference in chickpea yield.

Chickpea density effect

An increase in chickpea density to 30 plants/m^2 from 15 plants/m^2 resulted in a decrease in common sow thistle biomass in 36 per cent of environments. The magnitude of this decrease ranged from 37 to 74 per cent (Figures 11 and 12).

There was a greater common sow thistle biomass at one environment when a higher density of chickpea was grown and there was no difference at other environments, but a clear trend for a reduced weed biomass (Figure 12).

Common sow thistle seed production was less in 26 per cent of environments at a greater crop density (Figure 11) and no difference in the remainder of environments. The magnitude of reduction in seed production ranged from an average of 39 to 74 per cent.

Favourably, an increase in chickpea density resulted in an increase in chickpea yield across environments, with an average increase of 0.26t/ha.

Common sow thistle in chickpeas. Photo: QDPI

Combined row spacing and density effect

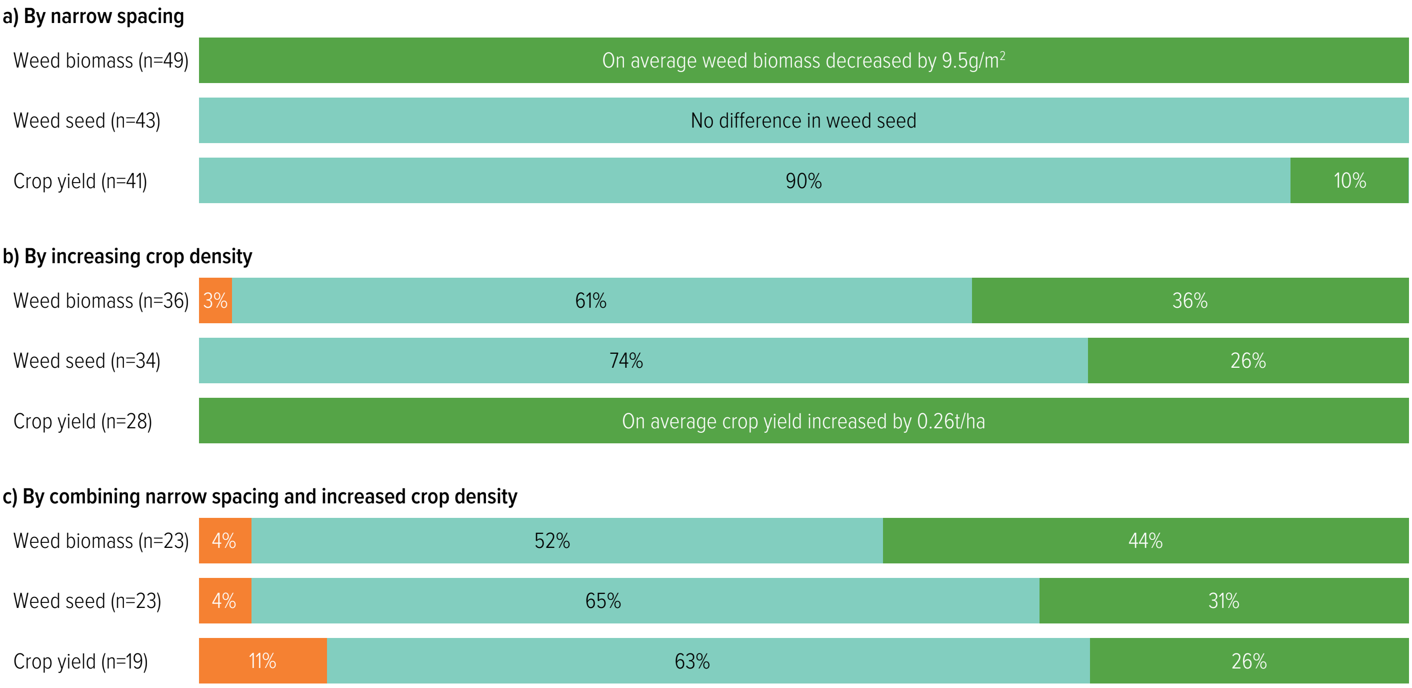
When a narrow row spacing of 25cm was combined with a greater crop density of 30 plants/m^2, there were variable responses for both weed and crop measures.

Common sow thistle biomass and seed production were reduced in 44 and 31 per cent of environments respectively. However, there was also an increase in both at one environment (4 per cent; Figure 11).

Chickpea grain yield was greater in 26 per cent of environments, in the more competitive chickpea configuration. However, there was an average yield penalty of 20 to 30 per cent in 11 per cent of environments (Figure 11).

Suppression of common sow thistle in chickpeas

Figure 11: Chickpea crop competition effects on common sow thistle growth and seed production across environments and chickpea yield where a) a reduction in row spacing to 25cm was compared to a row spacing of 50cm, b) an increased chickpea density of 30 plants/m² was compared with 15 plants/m², and c) a more competitive chickpea planted at a narrow row spacing of 25cm and an increased density of 30 plants/m² was compared with chickpeas planted at 50cm row spacing and 15 plants/m².



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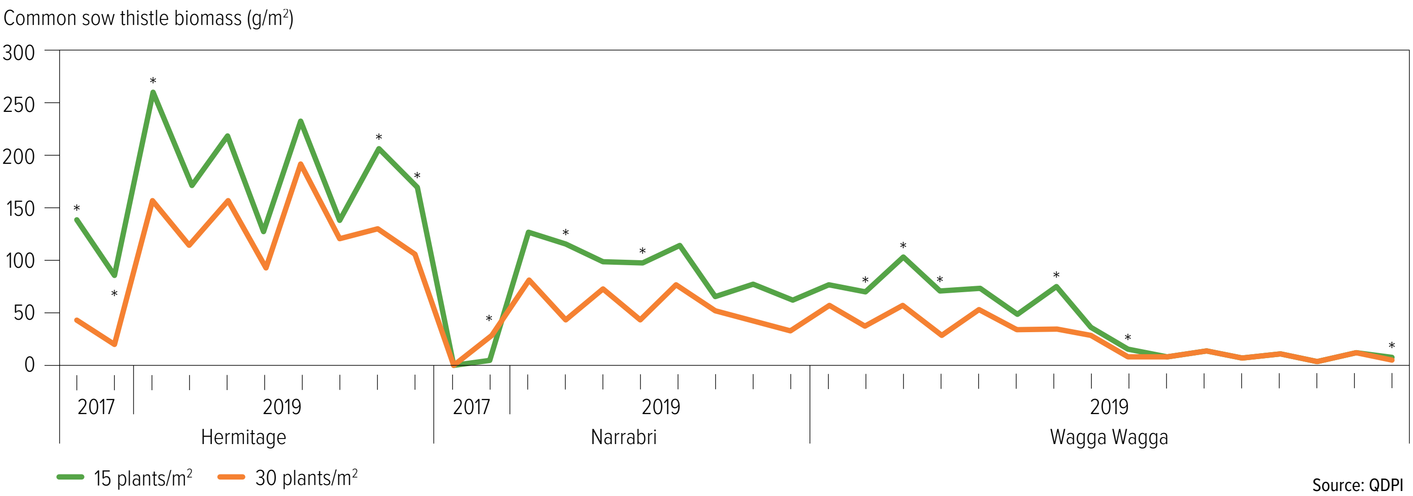
Source: QDPI

Figure 12: Chickpea density effects on common sow thistle biomass across environments.
* = a significant difference. Each vertical line on the x-axis denotes an environment, defined within a trial through the pairing of the same conditions (for example, cultivar, weed density) with both low and high levels of the agronomic factor.



Source: QDPI

Faba beans

Faba beans are commonly grown at wider row spacings of 30 to 54cm and even in skip-row configurations. However, it can be grown at row spacings as narrow as 18cm. The recommended plant density for faba beans in the northern region is 12 to 25 plants/m^2.

Row spacing effect

Growing faba beans at a narrow row spacing of 25cm compared to 50cm, reduced the biomass and seed production of common sow thistle in 38 and 24 per cent of environments respectively (Figure 13).

The average magnitude of reduction ranged from 35 to 83 per cent (biomass) and 36 to 71 per cent (seed production). A site-specific example of common sow thistle seed production as affected by row spacing is provided in Figure 14.

Favourably, narrow row spacing delivered increased faba bean yields across environments; the average being a 0.26t/ha (10 per cent) increase.

Faba bean density effect

A greater faba bean density of 30 plants/m^2 compared to 20 plants/m^2 resulted in reduced common sow thistle biomass and seed production at 33 and 23 per cent of environments respectively (Figure 13).

The average magnitude of reduction ranged from 37 to 74 per cent (biomass) and 44 to 89 per cent (seed production). A site-specific example of common sow thistle biomass reduction due to a greater faba bean density is shown in Figure 15. Faba bean yield was greater across environments at the greater crop density by an average of 0.20t/ha (seven per cent increase).

Common sow thistle in faba beans. Photo: QDPI

Combined row spacing and density effect

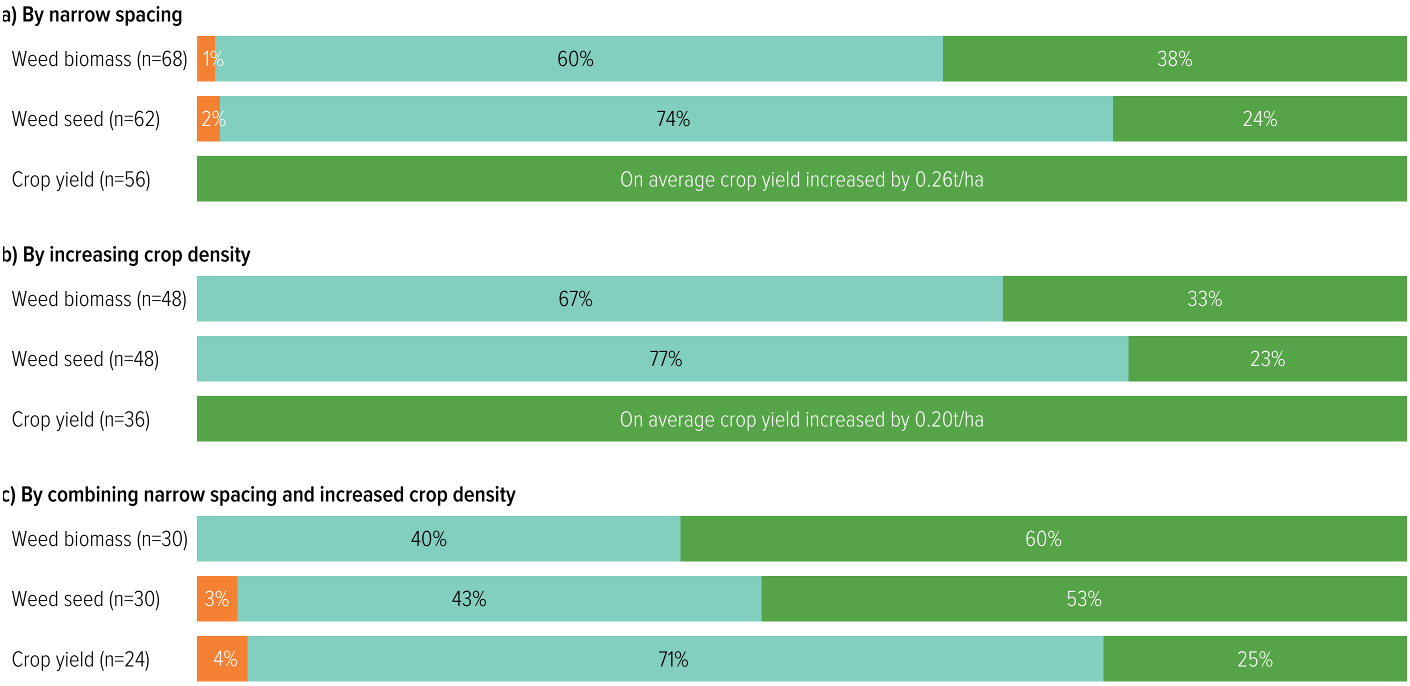
Growing faba beans at a combined narrow row spacing of 25cm and a greater crop density of 30 plants/m^2 resulted in reduced common sow thistle biomass and seed production at more of the environments than either row spacing or crop density alone (Figure 13).

The average magnitude of reduction was also greater with 47 to 87 per cent reduction for biomass and 45 to 95 per cent reduction for seed production.

Combining narrow row spacing and increased crop density resulted in an increased grain yield in 25 per cent of environments. The magnitude of increase was 15 to 43 per cent. However, in one environment, there was a yield reduction of 21 per cent (Figure 13). Figure 16 shows the overall trend for a greater faba bean yield under the more competitive crop configuration.

Suppression of common sow thistle in faba beans

Figure 13: Faba bean crop competition effects on common sow thistle growth and seed production across environments and on faba bean yield where a) a reduction in row spacing to 25cm was compared to a row spacing of 50cm, b) an increased faba bean density of 30 plants/m² was compared with 20 plants/m², and c) a more competitive faba bean crop planted at a narrow row spacing of 25cm and an increased density of 30 plants/m² was compared with faba beans planted at 50cm row spacing and 20 plants/m².



= a positive effect of either a decrease in weed growth (biomass) or seed production, or a gain in grain yield. = no significant difference. = a negative effect of either an increase in weed growth (biomass) or seed production, or a loss in grain yield. n = the number of environments and the per cent value in the bars is the per cent of environments where the result was observed. Where a bar is split into two or three colours, this indicates there was an interaction with the environment, whereas a single-coloured bar indicates a consistent main effect of the variables. Note: 'increases' or 'decreases' refers to significant increases or decreases, and 'no difference' or 'no effect' refers to no significant difference (at five per cent level of significance). Also, some rounded per cents will not add to 100 per cent due to the rounding process.

Source: QDPI

Figure 14: Common sow thistle seed production (per plant) as affected by faba bean row spacing (cm) at Narrabri, NSW 2019. Bars with no letters in common are significantly different at P = 0.05. Least significant difference for transformed data = 1.94.

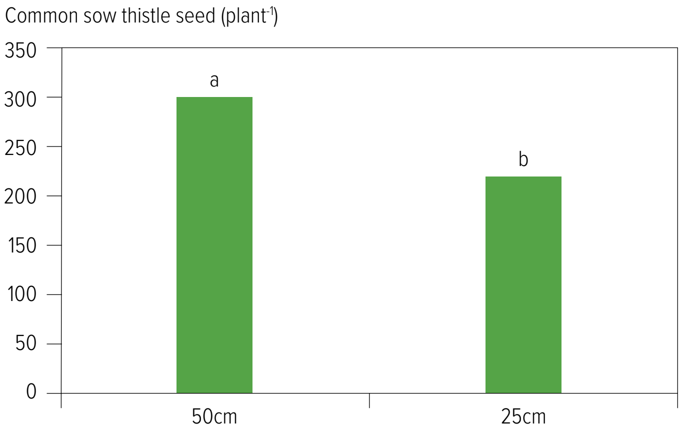
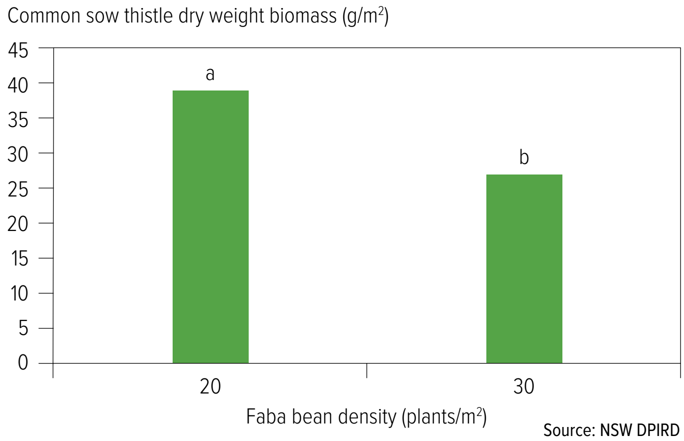
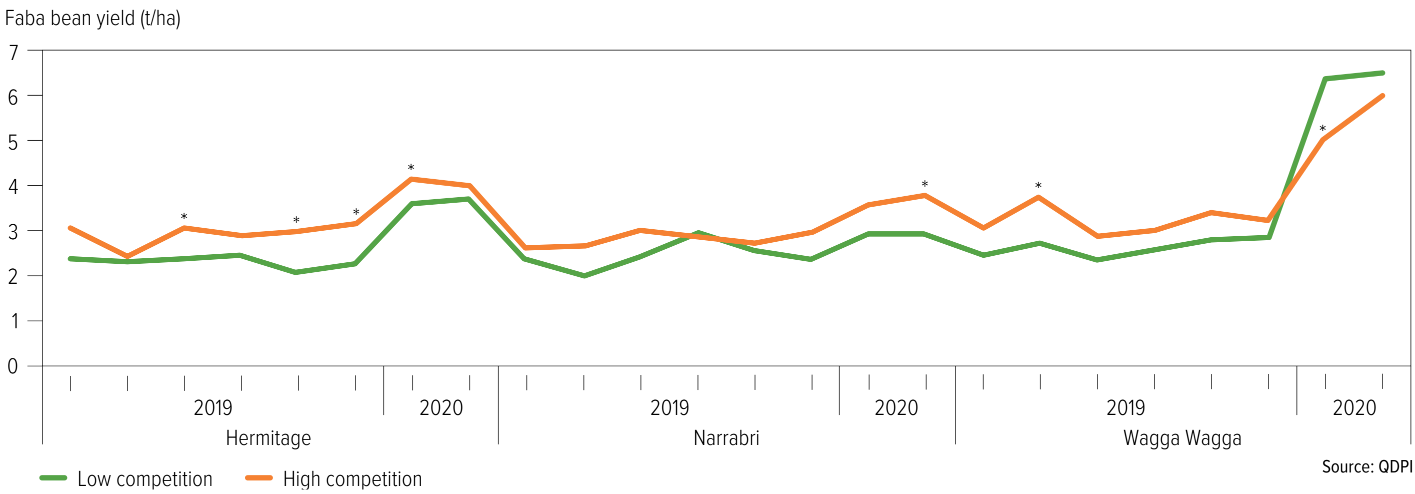


Figure 15: Common sow thistle dry weight biomass (g/m²) as affected by faba bean planting density (plants/m²) at Narrabri, NSW 2019. Bars with no letters in common are significantly different at P = 0.05. Least significant difference for transformed data = 0.79.



Source: NSW DPIRD

Figure 16: Faba bean crop competition effects on faba bean grain yield. Where low competition = 50cm row spacing and 20 plants/m², and high competition = 25cm row spacing and 30 plants/m². * = a significant difference. Each vertical line on the x-axis denotes an environment, defined within a trial through the pairing of the same conditions (for example, cultivar, weed density) with both low and high levels of the agronomic factor.



Source: QDPI

Conclusion

Key findings

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. This has been demonstrated for common sow thistle in chickpeas and faba beans, and for FTR and ABG in sorghum and mungbeans.

The results show that increased crop competition should be considered as a component of weed management programs.

Considerations for growing a competitive crop

Impacts on crop yield

A key consideration for growing a competitive crop using narrow row spacing and/or increased crop density is the impact on crop yield, especially in dry seasons or in low-rainfall regions.

As was seen for sorghum in 2021 (Figure 7), yield reduction under high competition can occur if limited resources, such as soil moisture, are available during flowering and grain fill.

In contrast, when there is a high yield potential, crops grown under high competition can result in yield gains being realised (Figure 7).

In our research, the more competitive crop configurations maintained crop yields 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 low rainfall. A more competitive crop will require more resources (for example, water) to retain or increase crop yield. The key lies in balancing competition against weeds without compromising crop productivity.

To spread yield loss uncertainty, it is recommended to grow competitive crops when resources are likely to be plentiful or only in select paddocks rather than a whole property.

Machinery challenges

Often farm operations have their machinery set to a consistent row spacing. Narrow row spacing will require a change to machinery, especially for planting. However, an increase in crop density will not require a machinery change and can still provide positive gains for weed suppression and crop grain yield.

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Resources

GrowNotes™– Mungbeans (2017). Grains Research and Development Corporation, grdc.com.au/data/assets/pdf_file/0014/315311/GRDC-GrowNotes-Mungbeans-Northern.pdf

GrowNotes™ – Faba beans (2017). Grains Research and Development Corporation, grdc.com.au/resources-and-publications/grownotes/crop-agronomy/fababeangrownotes

Pulse Australia website, pulseaus.com.au/growing-pulses/bmp/chickpea/northern-guide

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