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Implications of narrow crop row spacing in managing weeds in mungbean (*Vigna radiata*)

Bhagirath Singh Chauhan [a], Singarayer Kumardas Florentine [b, *], J. Connor Ferguson [c, d], Rodolfo G. Chechetto [e]

[a] *The Centre for Plant Science, Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland, Gatton, Toowoomba, Queensland, Australia*
[b] *Centre for Environmental Management, Faculty of Science and Technology, Federation University Australia, Mt Helen, Ballarat, PO Box 663, Vic 3350, Australia*
[c] *The University of Queensland, Gatton/Toowoomba, Queensland 4343/4350, Australia*
[d] *Northwest Missouri State University, Maryville, MO, 64468, USA*
[e] *AgroEfetiva Serviços SS Ltda, Botucatu, São Paulo, SP, 18603-760, Brazil*

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A B S T R A C T

The mungbean production area is increasing in Australia due to increasing demand for the grain in Asian countries. However, the mungbean crop is generally grown with wide row spacing, and therefore, it is prone to heavy weed infestation which has a significant impact on the mungbean grain yield. Experiments were conducted in 2015 and 2016 to determine the row-spacing impact on crop yield and weed growth for mungbean grown in 25, 50, and 75 cm space rows. Row spacing did not affect weed biomass and mungbean grain yield when weeds were allowed to grow from crop sowing to maturity. However, narrower row spacing (25 and 50 cm) had lower weed biomass and higher grain yield when weeds were allowed to grow beyond 3 and 6 weeks after planting (WAP). Mungbean grown at 25 and 50 cm rows had 60–70% and 70–92% less weed biomass than the mungbean grown at 75 cm rows for the weeds grown beyond 3 and 6 WAP, respectively. In weed-free conditions, too, mungbean grain yields were greater in narrow rows than in wider rows. Weeds grown beyond 6 WAP did not affect grain yield of 25 and 50 cm rows but reduced mungbean yield with 75 cm rows. The practical implication of this study is that narrowing row spacing in mungbean could lead to reduced weed growth and seed production and increased crop yield.

1. Introduction

Mungbean [*Vigna radiata* (L.) Wilczek], a nutritionally important grain legume, is grown in central and southern Queensland and Northern New South Wales in Australia. It is also grown as a rotation crop due to its ability to fix atmospheric nitrogen (Rachaputi et al., 2015). Approximately 95% of the total mungbean production in Australia is exported to different countries, including India, Vietnam, Philippines, and China and its demand is increasing. In general, mungbean is grown using wide row spacing of up to 1-m. A crop grown with wide row spacing is prone to heavy weed infestation due to the substantial space remains between these widely spaced crop rows for weeds to emerge. Weeds continue to emerge and produce seeds until they are controlled by tillage, herbicide, or using crop competition. Herbicides are widely used in Australia to manage weeds in mungbean; however, there are very limited post-emergence options, especially for broadleaf weeds. In addition, continuous use of herbicides with similar modes of action may result in the evolution of resistance in weeds. In Australia, for example, many summer weeds (e.g., *Sonchus oleraceaus* L. against glyphosate) have developed resistance to commonly used herbicides (Heap, 2016). Furthermore, the lack of release of new effective herbicides, weed population shifts, concerns over environmental pollution, and an increase in herbicide costs may limit the herbicide options in the future (Buhler et al., 2002; Chauhan, 2012; Bajwa et al., 2015). Therefore, there has been an interest to integrate cultural practices with other management practices to reduce reliance on herbicides and provide more effective weed control.

* Corresponding author.
E-mail address: s.florentine@federation.edu.au (S.K. Florentine).

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Cultural practices should aim to make the crop more competitive against weeds.

Reducing the row spacing is a cultural approach that can be included in integrated weed management programs to improve crop competitiveness against weeds (Chauhan and Johnson, 2010; Chauhan, 2012). In cereals, reducing the row spacing led to decreased weed growth and weed seed production (Chauhan and Johnson, 2010). Similarly, in soybean, weeds grown with the crop planted in 19-cm rows produced less dry matter and reduced soybean yield less than weeds grown in 76-cm rows (Hock et al., 2006). Another similar study suggested that planting soybean in wide rows reduces early-season crop tolerance to weeds and therefore, requires earlier weed management programs than crop planted in narrow rows (Knezevic et al., 2003). Other studies also found that soybean planted in 18-cm rows was more competitive against weeds than in 75-cm rows (Mulugeta and Boerboom, 2000; Knezevic, 2014). However, this information is not available for mungbean in Australian conditions.

A study was conducted to evaluate the impact of mungbean grown in 25-, 50-, and 75-cm rows on mungbean grain yield and weed growth. The knowledge gained from this study will contribute to developing better weed management packages for mungbean production.

2. Materials and methods

A field study was conducted from February to June 2015 (2015 season) and November 2015 to April 2016 (2016 season) at the research farm of the University of Queensland, Gatton, Queensland, Australia. The soil of the experimental site had a pH of 7.2; organic matter of 2.7%, nitrogen of 33 mg kg^{-1}, and phosphorus of 215 mg kg^{-1}. Prior to planting, the experimental area was cultivated three times, using a rotary hoe. Mungbean (*cv.* Jade-AU) seeds were planted using a tractor-mounted cone planter at a rate equivalent of 30 kg ha^{-1}. The crop was sown on 12 February 2015 and 27 November 2015 at 25-, 50-, and 75-cm row spacing. There were four weed infestation levels: weedy from sowing to maturity, weedy beyond 3 weeks after planting (WAP), weedy beyond 6 WAP, and weed-free from sowing to maturity. Due to non-uniform weed density at the experimental site, weed competition was created by spreading Rhodes grass (*Chloris gayana* Kunth) at 300 seeds m^{-2} at different times after crop planting (i.e., 0, 3, and 6 WAP). A light irrigation, using a sprinkler system, was performed immediately after spreading Rhodes grass to achieve its uniform emergence. No weeds were allowed to grow in the weed-free plots. This was achieved by spraying these plots with pendimethalin at 800 g ai ha^{-1} immediately after planting (as pre-emergence). Weeds emerged after the herbicide application were removed by hand. The size of each weed infestation plot was 24 m^2.

At 12 WAP (i.e., 6 weeks after the last weed seed spread), weed biomass was harvested within a 75 cm × 50 cm quadrat placing randomly two locations per plot. Weeds were sampled by cutting them at the ground level, and these were dried in an oven at 70 °C for 72 h to obtain constant biomass determination. Mungbean was harvested using a plot-harvester when 90% of plants had around 80% mature pods. The harvest area was 12-m^2 and grain yield was converted to kg ha^{-1} at 12% moisture content.

The experiments in both seasons were arranged as a randomized split-plot design with crop rows as the main plots and infestation level as the sub-plots. Each treatment was replicated three times in each year. Data were subjected to analysis of variance using GenStat 16th edition. Means were separated using the least significant difference at 5%.

3. Results

Weed biomass was affected by the interaction (<0.05) between crop row spacing and the weed infestation period in both seasons (Fig. 1). In both seasons, row spacing did not affect weed biomass when weeds were allowed to grow from crop sowing to maturity. However, the crop sown in 25- and 50-cm rows had lower weed biomass when weeds were allowed to grow beyond 3 WAP. In 2015, for example, weed biomass in 25–50 cm rows was 35–46 g m^{-2} compared to 75 cm rows (117 g m^{-2}) for the weeds grown beyond 3 WAP. These values were 5–9 g m^{-2} in 25–50 cm rows compared to 56 g m^{-2} in 75 cm rows when weeds allowed to grow beyond 6 WAP. Similar trend was found for weed biomass in 2016. There was 60–70% weed biomass reduction in the crop grown at 25–50 cm rows compared to the crop grown at 75 cm rows for the weeds grown beyond 3 WAP. These values reduced significantly when weeds were allowed to grow beyond 6 WAP; 70–92% reduction in weed biomass in 25–50 cm rows compared to 75 cm rows. Weed biomass was recorded similar between 25 and 50 cm rows.

As with the weed biomass, the grain yield of mungbean was also affected by the interaction between crop row spacing and weed infestation period in both seasons (Fig. 2). In both seasons, grain yield was not affected by row spacing when weeds were allowed to grow from crop sowing to maturity. In these plots (completely weedy), yields ranged from 200 to 360 kg ha^{-1} in 2015 and 110–180 kg ha^{-1} in 2016. When weeds were allowed to grow beyond 3 WAP, the crop sown at 25 and 50 cm rows always produced higher grain yield than the crop sown at 75 cm rows. The percent increase in grain yield in 25 and 50 cm rows was 159–197% in 2015 and 198–223% in 2016 compared to yield in 75 cm rows. The crop sown at 75 cm rows (1620 kg ha^{-1} in 2015 and 1220 kg ha^{-1} in 2016) had also lower yield in the completely weed-free conditions compared to the crops sown at 25 and 50 cm rows (2030–2200 kg ha^{-1} in 2015 and 1650–1820 kg ha^{-1} in 2016). For the crops sown at 25 and 50 cm rows, the grain yield was similar between the weed-free plots and the plots in which weeds were allowed to grow beyond 6 WAP. Irrespective of the weedy situation, grain yield was always similar between 25 and 50 cm rows.

4. Discussion

The current study shows that narrow row spacing (25 and 50 cm) in mungbean suppressed weed growth more than wide row spacing (75 cm). These results concur with those of others in suggesting that reducing row spacing decrease weed biomass (Mulugeta and Boerboom, 2000; Clay et al., 2005; Chauhan and Johnson, 2010). A previous study, reported that soybean planted at 18 and 38 cm was more competitive against weeds than the crop planted at 76 cm (Mulugeta and Boerboom, 2000). A later study in soybean also reported lower weed biomass in the crop grown at 19 cm rows vs. 76 cm rows (Hock et al., 2006). Improved weed suppression in narrow rows in this study and previous studies could be the result of fast or early canopy closure compared to crops grown with wide rows, affecting light penetration to the soil surface and reducing weed growth (Knezevic et al., 1999). In corn, the use of narrow spacing was suggested to minimize the addition of weed seeds to the soil seed bank and therefore, depleting it progressively in the soil (Mashingaidze et al., 2009). Although we did not take weed seed production data in this study, published studies suggest that weed seed production is linearly related to weed biomass (Chauhan and Johnson, 2010). Therefore, growing mungbean in narrow rows may also help to reduce weed seed bank in Australian conditions.

Irrespective of the weed infestation period, grain yield of mungbean was higher in 25 and 50 cm rows than in 75 cm rows,

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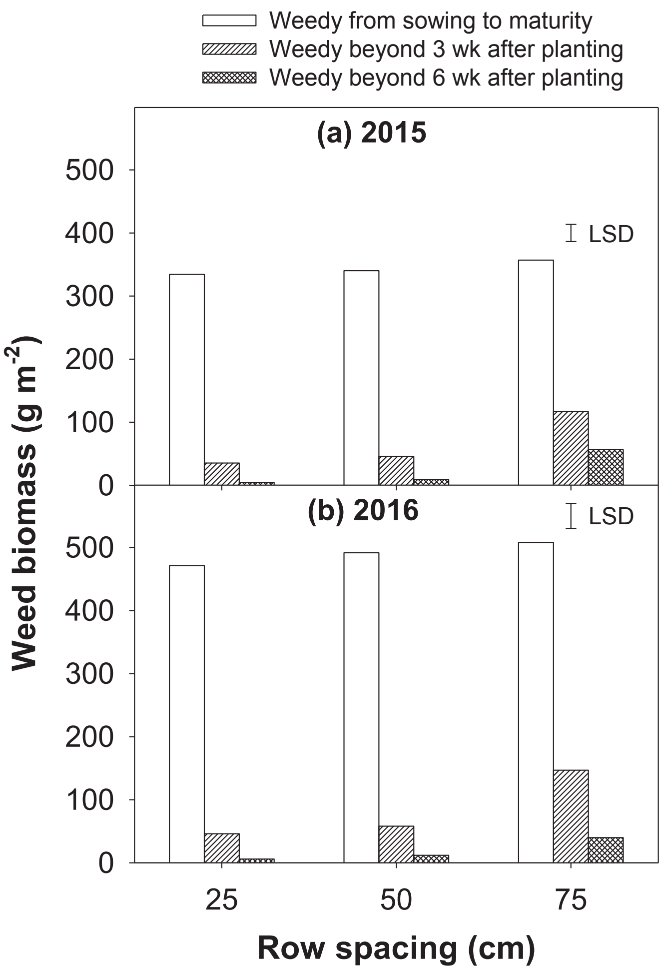

Fig. 1. Interaction effect of mungbean row spacing and weed infestation period on weed biomass in 2015 (a) and 2016 (b).

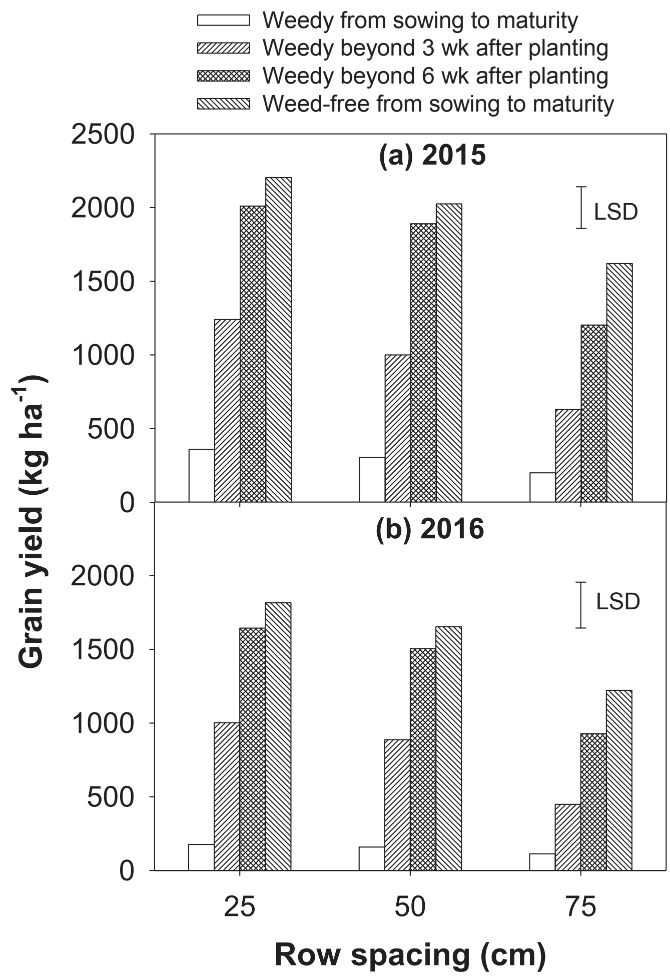

Fig. 2. Interaction effect of crop row spacing and weed infestation period on mungbean grain yield in 2015 (a) and 2016 (b).

suggesting that narrow row spacing may produce higher grain yield even in weed-free conditions. These results are in agreement with a recent study conducted in weed-free conditions in the northern grain region of Australia, where narrow row spacing (30–50 cm) produced 14% higher yields of mungbean compared to wide rows (90–100 cm) (Rachaputi et al., 2015). The study suggested that the increased yield was due to a 22% increase of intercepted radiation in narrow rows. The study also observed increased mungbean dry matter in narrow rows, which the authors suggested could be due to rapid canopy development, leading to increased cumulative intercepted radiation and increased soil water uptake. The results of the previous and this study suggest that narrow row spacing can produce higher biomass and thus, contribute more nitrogen to the following cereal crops (Kirkegaard et al., 2008; Rachaputi et al., 2015). Such benefits are considered very important from a crop rotation standpoint in the northern region of Australia.

Our data shows that weeds grown beyond 6 WAP did not reduce mungbean grain yield compared to the weed-free conditions in 25 and 50 cm rows. However, this was not true for the crop grown at 75 cm rows, where grain yield was higher in the weed-free plots compared to the plots where weeds were allowed to grow beyond 6 WAP. Results suggest that the critical weed-free periods for the 75 cm rows are longer than the other two row spacings. Mungbean in wide rows therefore, would require longer weed management programs than in narrower rows. The information gained from this study suggests that mungbean should be grown in narrow rows and kept weed-free for the first 6 weeks but beyond 6 weeks, there is very little benefit of subsequent weed control (Chauhan and Johnson, 2011). Due to the depletion weed seed bank in the soil, growers may have to extend their weed control practices beyond 6 WAP to prevent late emerging weeds from producing seeds. A previous study in aerobic rice reported longer critical weed-free periods for the crop grown at 30 cm rows compared to that at 20 cm rows (Chauhan and Johnson, 2011), which confirms this study's results. A study in soybean reported that planting the crop in wide rows reduced early season crop tolerance to weeds and therefore, required earlier weed management programs than in narrower rows (Knezevic et al., 2003).

Our study was conducted at a single location; however, different environmental conditions (e.g., drought) may affect weed growth and crop yield differently. Therefore, there is a need to investigate the genotype by environment by management interactions on weed growth and mungbean yield at different row spacing. We used Rhodes grass, a cultivated species, to simulate weeds. A cultivated species may respond differently than 'real' weeds and therefore, there is a need to conduct future studies with different problematic weed species in mungbean. Demonstrating the negative effect of narrow row spacing on weed growth, seed production and weed seed bank in the soil could be the most important implication to convince growers to change their row spacing, especially with increased herbicide-resistant weed incidence.

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