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Abstract: Field studies were conducted in southern Queensland to determine the impact of sorghum cultivars and crop densities on weed suppression and sorghum yield loss due to weeds. Japanese millet (Echinochloa esculenta (A. Braun) H. Scholtz) was used to mimic barnyard grass (Echinochloa spp.). Results showed that differences in competitive ability of the cultivars were consistent over the two years, with MR Goldrush and Bonus MR being the most competitive cultivars, and 86G87 the least competitive. Sorghum density also had a significant effect on the crops ability to compete with millet, with the strongest millet suppression at the highest density of 7.5 plants m-2. Millet caused significant yield loss, up to 34% in comparison with weed-free plots. These results indicate that sorghum competition against Japanese millet can be improved by choosing competitive cultivars and the use of higher crop densities. Improved sorghum competition provides a non-chemical option for integrated weed management.

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Competitive effects of sorghum cultivars and densities on weed suppression

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Summary Field studies were conducted in southern Queensland to determine the impact of sorghum cultivars and crop densities on weed suppression and sorghum yield loss due to weeds. Japanese millet (*Echinochloa esculenta* (A. Braun) H. Scholtz) was used to mimic barnyard grass (*Echinochloa* spp.). Results showed that differences in competitive ability of the cultivars were consistent over the two years, with MR Goldrush and Bonus MR being the most competitive cultivars, and 86G87 the least competitive. Sorghum density also had a significant effect on the crop's ability to compete with millet, with the strongest millet suppression at the highest density of 7.5 plants m^{-2}. Millet caused significant yield loss, up to 34% in comparison with weed-free plots. These results indicate that sorghum competition against Japanese millet can be improved by choosing competitive cultivars and the use of higher crop densities. Improved sorghum competition provides a non-chemical option for integrated weed management.

Keywords sorghum competition, cultivar, crop density, weed management.

INTRODUCTION

The cropping system of dryland sorghum is complex, as it involves a number of different rotational crops in combination with variable length fallows in the northern grains region. The amount of stored soil moisture before sowing is usually the most critical factor limiting dryland sorghum production. Weeds have caused sorghum yield losses of up to 65% (Holland and McNamara 1982). Walker *et al.* (2005) estimated that weeds cost Australian sorghum growers approximately \$93 ha^{-1} per season in applying control measures and lost production.

A diverse range of broadleaf and grass weeds have been shown to affect sorghum production. A recent survey has identified barnyard grass, liverseed grass (*Urochloa panicoides* Beauv.) and bladder ketmia (*Hibiscus trionum* L.) as some of the most common weeds in sorghum in northern grains region (Walker *et al.* 2005).

Farmers rely heavily on a few herbicides such as atrazine, metolachlor and fluroxypyr for weed control in sorghum,. Heavy reliance on herbicides has increased the risk of developing herbicide resistance. Several weeds including liverseed grass populations have already developed resistance in this region (Adkins *et al.* 1997). A biotype of awnless barnyard grass (*Echinochloa colona* L. Link) resistant to glyphosate has been recently identified in this region (Heap 2007). This has prompted recognition of the urgent need for non-chemical control options.

Enhanced crop competitiveness has become an integral component of management systems to improve weed control, reduce herbicide usage and combat herbicide resistance (Lemerle *et al.* 2001, Walker *et al.* 2002). Sorghum competition studies with weeds are limited. The objectives of this study were to determine if current commercial sorghum cultivars differ in competitiveness with weeds and if high crop densities can be used to improve weed suppression.

MATERIALS AND METHODS

Field experiments and design Field experiments were conducted over two sorghum growing seasons between 2003-2005 at two sites near Toowoomba, southern Queensland. The six most widely grown sorghum cultivars in this region, 85G83, 86G87, Bonus MR, Pacific MR43, MR Buster, and MR Goldrush were chosen, based on their different growth characteristics, such as maturity, early vigour, tillering and staygreen. In the 2003-04 season, the experiment was arranged in an incomplete factorial design with six cultivars, three sorghum densities (4.5, 6.0, and 7.5 plants m^{-2}), and two weed infestations (weedy and weed-free). Only two sorghum cultivars (MR Buster and MR Goldrush) received the weed-free treatments in order to determine the impact of weeds on sorghum yield. The 2004-05 experiment was arranged in a full factorial, randomised complete block design with the same six sorghum cultivars and the three plant densities in the presence and absence of weeds. Three replications were used in both field experiments. Japanese millet was used to mimic barnyard grass (*Echinochloa* spp.) and was artificially infested to achieve a target density of 80 plants m^{-2} in the weedy plots.

Sorghum was planted in October/November on the industry standard row spacing of 1 m. The plot size was 60 m^2. No fertilisers were used in either of the experiments due to the use of legume crops in previous rotations. Weed-free controls were achieved by applying a mixture of atrazine (1.25 kg a.i. ha^{-1}) plus fluroxypyr (100 g a.i. ha^{-1}) as well as by manual hoeing. Sorghum was harvested in March. Both experiments experienced very favourable seasons with a total amount of rainfall 375 - 377 mm received during the growing periods.

Measurements At sorghum maturity, millet density, biomass, height, and seed production were measured using two 1 x 1 m quadrats randomly placed between the sorghum rows. Millet plants were cut at ground level for biomass assessment. Fresh weight m^{-2} was determined in 2003-04 experiment, while dry weight m^{-2} was obtained in 2004-05 experiment. The millet samples from the two 1 x 1m quadrats were assessed for total number of effective panicles, seed weight of 10 representative panicles, and 300-seed weight, which were used to calculate millet seed production m^{-2}. Sorghum was harvested for yield assessment after desiccation with glyphosate (900 g a.i. ha^{-1}) at maturity.

Statistical analysis Data from the two experiments were initially analysed for any significant yearly interactions with sorghum cultivar and crop density. Since there were no significant interactions of year × cultivar and year × crop density, experimental data were pooled and analysed. To obtain homogeneity of variance, data for millet weights were transformed as ln10(x+1) before analysis, while millet counts were square root transformed. Back-transformed data are presented. The data were subjected to analysis of variance using GenStat 8th edition (Release 8.1) using actual sorghum density as a covariate. Treatment means were tested separately with least significant difference (l.s.d) at a 5% level of probability.

RESULTS

Effects of sorghum cultivar on weed growth and seed production Sorghum cultivars differed significantly in their competitiveness with millet as reflected in the millet density, biomass m^{-2} and millet seed production m^{-2} at crop maturity. The cultivar 86G87 had the highest weed density and seed production, and the second highest millet biomass m^{-2} (Table 1). Compared to 86G87, MR Goldrush was strongly competitive, causing 19% reduction in weed density, 31% in biomass and 34% in weed seed production. Bonus MR was also very competitive, significantly reduced millet biomass, numbers of panicles, and the numbers of seeds m^{-2} produced at the end of the season.

Table 1. Competitive effects of sorghum cultivars and crop densities on millet growth at crop maturity. Cultivar data are the means of three crop densities and crop density data are the means of the six cultivars. Millet biomass was measured as fresh weight in 03-04 and dry weight in 04-05. Means followed by the same letters are not significantly different (P > 0.05).

Treatment	Millet growth traits and seed production			
	Density (m^{-2})	Biomass ($g\ m^{-2}$)		Seed production (m^{-2})
		03-04	04-05	
Cultivar				
Pacific MR43	45^{ab}	846^{ab}	288^{a}	57600^{bc}
85G83	46^{ab}	955^{ab}	396^{b}	60100^{c}
86G87	51^{b}	1068^{b}	380^{b}	68400^{c}
Bonus MR	44^{ab}	763^{a}	263^{a}	47400^{ab}
MR Buster	46^{ab}	1086^{b}	285^{a}	61300^{c}
MR Goldrush	42^{a}	754^{a}	247^{a}	45300^{a}
Crop density (plants m^{-2})				
4.5	50^{b}	1228^{b}	354^{b}	62800^{b}
6.0	46^{ab}	1098^{ab}	295^{a}	53700^{a}
7.5	41^{a}	958^{a}	280^{a}	53500^{a}

The reduction in weed seed production is a result of a combination of reduced numbers of panicles per plant and reduced seed production per panicle. Millet seed production m^{-2} was closely associated with millet density (Figure 1A) and millet biomass (Figure 1B). Excessive millet growth (biomass) caused a reduction in weed seed production in the second experiment, suggesting increased inter- and intra-specific competitions at a higher millet biomass.

Effects of crop density on weed growth and seed production Analysis of pooled data showed that crop densities had significant effects on millet density, biomass and seed production (Table 1). A high crop density of 7.5 plants m^{-2} was more competitive than the crop density of 4.5 plants m^{-2}. Increasing crop densities significantly reduced millet biomass. Sorghum at a density of 7.5 plants m^{-2} caused 17% reduction in weed density, 22% in biomass, and 15% in weed seed production, when compared to the crop density of 4.5 plants m^{-2}. The results indicated that a higher crop density should be achieved for better weed suppression, especially with poorly competitive sorghum cultivars, such as 86G87.

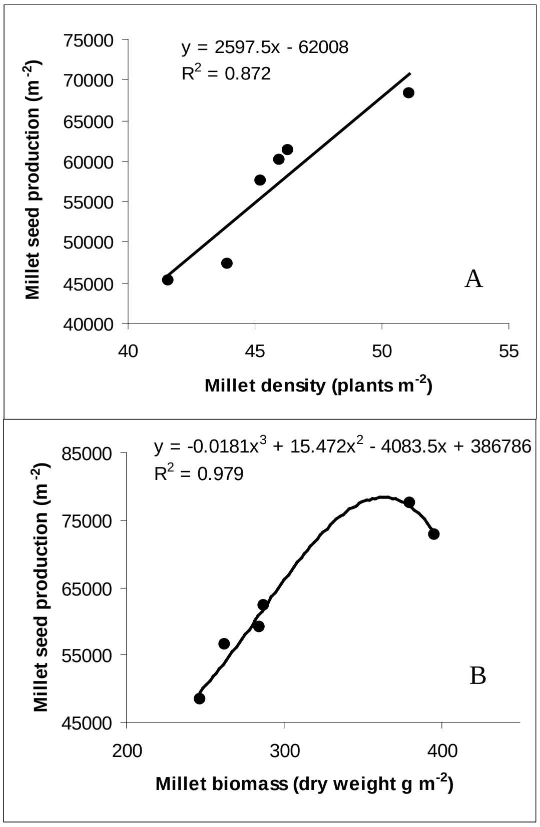

Figure 1. Effects of millet density (A, combined 03-04 and 04-05 data) and biomass (B, 04-05 data) on seed production.

Table 2. Sorghum yield as a result of millet competition. Means followed by the same letters are not significantly different (P > 0.05). Sorghum yields from weedy plots were pooled for the two experiments of six cultivars at three crop densities.

Treatment	2004-05		Pooled
	Height (cm)	Yield ($t\ ha^{-1}$)	Yield ($t\ ha^{-1}$)
Millet			
Absence	127^{a}	6.6^{b}	na
Presence	125^{a}	5.0^{a}	4.5
Cultivar			
Pacific MR43	123^{b}	5.9^{a}	4.4^{a}
85G83	130^{d}	5.9^{a}	4.4^{a}
86G87	127^{c}	5.5^{a}	4.2^{a}
Bonus MR	130^{d}	6.0^{a}	4.9^{a}
MR Buster	119^{a}	5.7^{a}	4.4^{a}
MR Goldrush	124^{b}	6.0^{a}	4.6^{a}
Crop density (plants m^{-2})			
4.5	125^{a}	5.6^{a}	4.1^{a}
6.0	126^{a}	5.9^{ab}	4.4^{ab}
7.5	126^{a}	6.0^{b}	4.9^{b}

Effects of weeds on sorghum yield Data from the 2004-05 experiment showed that millet caused 24% reduction in sorghum yield. There were no significant yield differences between the six sorghum cultivars. However, sorghum yield advantage with high crop density was evident in both experiments (Table 2). Combined data analysis of the weedy plots across the 2003-04 and 2004-05 experiments showed that sorghum planted at 7.5 plants m^{-2} yielded 20% more than the yield at the crop density of 4.5 plants m^{-2}.

Separate analysis of the two sorghum cultivars MR Buster and MR Goldrush, which were included in both experiments at the three crop densities in the presence and absence of millet, shows that millet reduced yield by up to 18% depending on the year, sorghum cultivar and crop density (Figure 2). Yield reduction in MR Buster at a density of 4.5 plants m^{-2} was 34% and 29% in 2003-04 and 2004-05 experiments, respectively. Sorghum yield loss due to millet also varied with crop densities. Yield loss decreased as crop densities increased (Figure 2). Based on MR Buster and MR Goldrush in the 2003-04 experiment, competition from millet caused 28%, 9%, and 4% yield reduction at sorghum densities of 4.5, 6.0, and 7.5 plants m^{-2}, respectively.

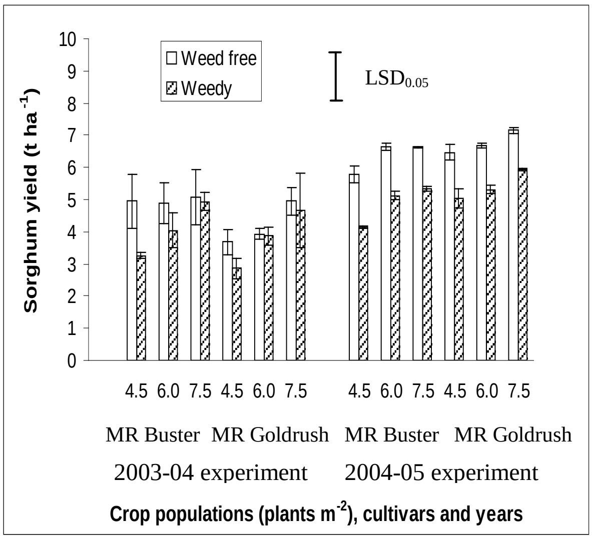

Figure 2. Interactions of cultivar and crop density on yield loss.

DISCUSSION

The present study has shown that planting competitive cultivars and/or increasing crop density can improve sorghum competition against weeds and potentially minimise yield loss due to weeds. The differential competitiveness of sorghum was previously reported to be associated with plant height and high leaf area index (LAI) (Traoré *et al*. 2003). However, sorghum height at maturity did not appear to reflect differences in competitiveness. For example, the poorly competitive cultivar, 85G83 (Table 1), in fact was the tallest among the six cultivars tested (Table 2). A high LAI might be a critical factor contributing to sorghum competition with millet. Leaf area duration is another useful indicator of crop competitiveness with weeds (Radosevich *et al*. 1997). A sorghum cultivar with staygreen traits might contribute to maintaining high LAI and prolonging leaf area duration, thereby suppressing the growth of weed survivors and late-emerging weeds.

Evidence has accumulated that sorghum possesses allelopathic activity against weeds through root exudation of a range of herbicidal allelochemicals, including sorgoleone (Weston and Czarnota 2001). Sorghum accessions can vary in the amount of exudates produced and the chemical constituents of each exudate (Czarnota *et al*. 2003), which might partly contribute to the differential competitiveness among the six cultivars in this study.

Improved crop competitiveness could suppress weed growth and reduce seed production. It has been shown that small changes in seed production will significantly influence the size of the seedbank and reduce subsequent weed pressure (Gonzalez-Andujar and Fernandez-Quintanilla 2004). More competitive sorghum crops would have significant long-term benefits for weed management via reducing the addition of new weed seeds to the soil seedbank. This increased competitiveness could be particularly important in situations where weed populations are small.

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REFERENCES

Adkins, S.W., Wills, D., Boersma, M., Walker, S.R., Robinson, G., McLeod, R.J. and Einam, J.P. (1997). Weeds resistant to chlorsulfuron and atrazine from the north-east grain region of Australia. *Weed Research* 37, 343-9.

Czarnota, M.A., Rimando, A.M. and Weston, L.A. (2003). Evaluation of root exudates of seven sorghum accessions. *Journal Chemical Ecology* 29, 2073-83.

Gonzalez-Andujar, J.L. and Fernandez-Quintanilla, C. (2004). Modelling the population dynamics of annual ryegrass (*Lolium rigidum*) under various weed management systems. *Crop Protection* 23, 723-9.

Heap, I. (2007). The International Survey of Herbicide Resistant Weeds. Online. October 29, 2007. Available www.weedscience.com.

Holland, J.F. and McNamara, D.W. (1982). Weed control and row spacing in dry-land sorghum in northern New South Wales. *Australian Journal of Experimental Agriculture and Animal Husbandry*. 22, 310-6.

Lemerle, D., Verbeek, B. and Orchard, B. (2001). Ranking the ability of wheat varieties to compete with *Lolium rigidum*. *Weed Research* 41, 197-209.

Radosevich, S., Holt, J. and Ghersa, C. (1997). 'Weed ecology: Implications for management'. (John Wiley & Sons, New York).

Traoré, S., Mason, S.C., Martin, A.R., Mortensen, D.A. and Spotanski, J.J. (2003). Velvetleaf interference effects on yield and growth of grain sorghum. *Agronomy Journal* 95, 1602-7.

Walker, S.R., Medd, R.W., Robinson, G.R. and Cullis, B.R. (2002). Improved management of *Avena ludoviciana* and *Phalaris paradoxa* with more densely sown wheat and less herbicide. *Weed Research* 42, 257-70.

Walker, S.R., Taylor, I.N., Milne, G., Osten, V.A., Hoque, Z. and Farquharson, R.J. (2005). A survey of management and economic impact of weeds in dryland cotton cropping systems of subtropical Australia. *Australian Journal of Experimental Agriculture* 45, 79-91.

Weston, L.A. and Czarnota, M.A. (2001). Activity and persistence of sorgoleone, a long-chain hydroquinone produced by *Sorghum bicolor*. *Journal of Crop Production* 4, 363-377.