Triticale competitive ability with annual ryegrass (*Lolium rigidum* Gaudin) as affected by variety, sowing rate and row spacing

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Summary One strategy for dealing with herbicide resistant weeds is to identify strongly competitive crop cultivars that suppress weed growth and/or withstand the competitive effects of weeds. Triticale (X *Triticosecale* Wittmack) is often ranked as more tolerant to environmental stresses than wheat (*Triticum aestivum* L.), however, little is known about varietal differences in its competitive ability with weeds. Annual ryegrass (*Lolium rigidum* Gaudin) is one of the most serious weed species in Australian cereal cropping largely because it has evolved herbicide resistance, is widespread and competes strongly with grain crops. A field trial was conducted to examine the competitive ability of four triticale cultivars and one wheat cultivar against annual ryegrass as influenced by row spacing (15 or 30 cm) and sowing rate (50 or 100 kg ha^{-1}). Cultivar Bogong had the highest grain and biomass yield of the triticale cultivars in the ryegrass-free treatment. In contrast, cultivars KM10 and Tuckerbox demonstrated greater competitive ability than the other triticale cultivars by sustaining smaller growth reductions when grown with ryegrass (10.4 and 8.5% biomass reduction, respectively). No interactions were observed with row spacing and sowing rate. The comparative wheat cultivar Spitfire had a lower grain yield and biomass than the triticale cultivars in both ryegrass treatments. There appears to be scope for utilising triticale competition in weed management, however, the optimal agronomy may vary with the cultivar.

Keywords Grain yield, biomass, herbicide resistance, wheat, cultivar.

INTRODUCTION

Annual (or rigid) ryegrass (*Lolium rigidum* Gaudin) is a problematic weed in Australian winter cereal cropping systems (McGillon and Storrie 2006). Previous studies have shown that many populations have developed resistance to herbicides such as glyphosate and diclofop-methyl (Christopher *et al.* 1991, Powles *et al.* 1998, Owen *et al.* 2007). In addition, it strongly competes with grain crops such as wheat (*Triticum aestivum* L.), causing significant yield losses (Wu *et al.* 1998). Annual ryegrass is one of at least 142 weed species worldwide that are resistant to more than one mode-of-action (MOA) group including 7 MOA groups which are no longer effective against many weed species (Heap 2018). Herbicide resistance development in weed species, particularly in Australia (Lemerle *et al.* 2004), has encouraged many researchers and farmers to examine alternatives to herbicides in weed control and improving cereal crop production.

Increasing crop competitive ability against weeds through manipulations of either sowing rates or row spacing is suggested for reducing yield losses due to weeds in wheat cropping systems (Lemerle *et al.* 2004, Mason *et al.* 2007). A wheat density of 120–240 plants m^{-2} can reduce ryegrass competition and achieve high grain yield (Tanji *et al.* 1997). Koscelny *et al.* (1990) stated that decreasing wheat crop row spacing to less than 18 cm could result in higher wheat yield by 5–7% due to increased efficiency of resource utilisation (Holliday 1960, Auld *et al.* 1983). Crop varietal selection is another factor that may change crop competitiveness through giving yield improvement and weed suppression; however, the cultivar competitive benefit can be influenced by the interaction of environment (including management) and genotype (Lemerle *et al.* 2001).

The use of vigorous crop varieties and optimised planting configurations could help improve crop competitiveness and thus manage herbicide resistance, potentially reducing costs and increasing yield. While some studies have shown that manipulation of sowing rates, row spacing and crop cultivars is effective for improving wheat competitive ability with weeds like annual ryegrass (Lemerle *et al.* 2004, Olsen *et al.* 2006, Beres *et al.* 2010a), and some studies with other weeds have included triticale (X *Triticosecale* Wittmack) (e.g. (Beres *et al.* 2010b), no studies exist in Australia or globally that focus on triticale competitiveness against annual ryegrass. Therefore, this experiment aimed to investigate the influence of cultivar, crop sowing rate and row spacing on triticale competitiveness with annual ryegrass.

MATERIALS AND METHODS

A field experiment was carried out during winter 2015 at the Laureldale Research Station, University of New England, Armidale NSW (latitude 30.515° S and longitude 151.665° E). The weather in 2015 was relatively warm (average 21.4°C) and the average monthly rainfall was 54.6 mm from August-December (Burr 2016).

Four triticale lines (cultivars Tuckerbox, Tobruk, Bogong and KM10) and one comparative wheat cultivar (Spitfire) were planted in early August 2015. Two sowing rates (50 and 100 kg ha^{-1}), two row spacing treatments (15 and 30 cm) and two ryegrass treatments (with and without) were used in this experiment with four replicates. The plots were 1.8 m by 5 m and 1.65 m by 5 m for 30 and 15 cm row spacings respectively. A randomised complete block design was used. Annual ryegrass seeds were harvested from a commercially grown crop in Victoria, Australia, and sown at 1.8 g m^{-2} to produce approximately 300 plants m^{-2} (Lemerle *et al.* 2013). The seeds were mixed with sand (Lemerle *et al.* 2013) and were distributed on each plot by hand immediately prior to crop planting on 7 August 2015. The broadleaf weed species which grew in the plots were; *Polygonum aviculare* L., *Sonchus oleraceus* L., *Amaranthus* sp., *Vicia* sp., *Trifolium* sp. and *Daucus carota* L.

Measurements The samples, taken at crop maturity, included four 1 m length rows for the 30 cm row spacing and eight 1 m length rows for the 15 cm row spacing treatments respectively. The crop biomass (t ha^{-1}) and grain yield (t ha^{-1}) were recorded.

Data analysis The total biomass and grain yield data were analysed with generalised linear models and lsmeans in R version 3.1.2 (R Core Team 2015). Model structures were simplified using a reduction in Akaike Information Criteria values as the criteria, while residuals were checked after analysis to validate the models used.

RESULTS

There was a highly significant interaction between crop cultivar, sowing rate and row spacing ($P<0.01$) in terms of the crop grain yield. Bogong had the greatest grain yield at high sowing rate (100 kg ha^{-1}) and wide row spacing (30 cm), about 4.21 t ha^{-1}, followed by Tobruk at about 4.10 t ha^{-1} in the same treatment. In contrast, the wheat cultivar Spitfire had its greatest grain yield at the low sowing rate (50 kg ha^{-1}) and narrow row spacing (15 cm), about 3.39 t ha^{-1} and had the lowest grain yield at high sowing rate with either narrow or wide row spacing in comparison with triticale cultivars (Figure 1).

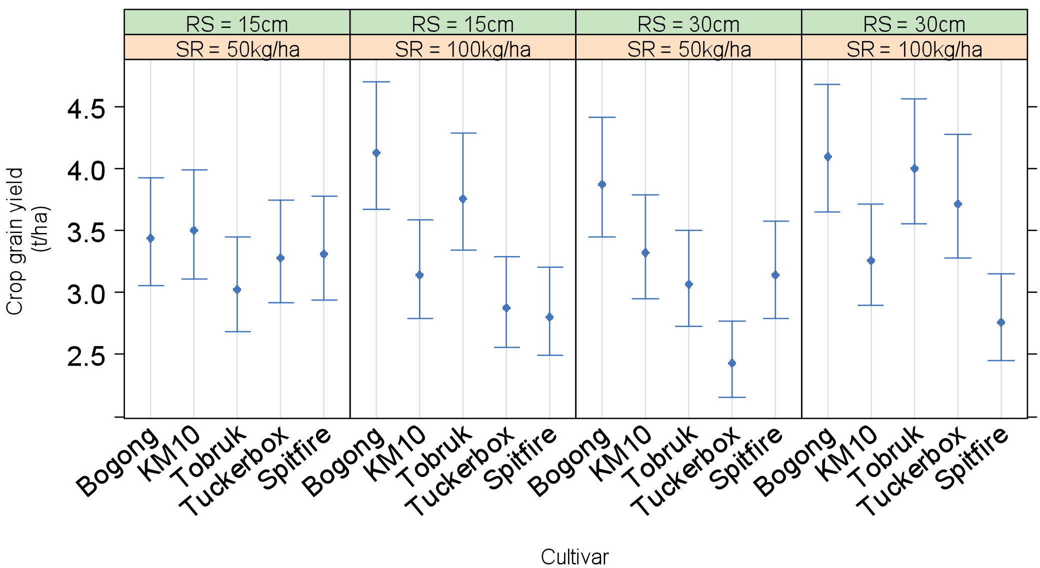

Figure 1. The effect of crop cultivar, row spacing (RS = 15 cm and 30 cm) and sowing rate (SR = 50 kg ha^{-1} and 100 kg ha^{-1}) on the crop grain yield. The error bars show the 95% confidence intervals.

Tuckerbox grain yield declined as row spacing increased at the 50 kg ha^{-1} sowing rate but increased as row spacing increased at 100 kg ha^{-1}. Other varieties were not significantly affected by row spacing (Figure 1). Tobruk appeared to respond positively in grain yield to increasing sowing rate from 50 kg ha^{-1} to 100 kg ha^{-1} at both row spacings. Likewise, Tuckerbox responded to increasing sowing rate at the 30 cm spacing. Other cultivars were not affected (Figure 1).

There was a significant interaction between crop cultivar and ryegrass treatment for crop biomass ($P<0.05$). Bogong had the greatest biomass with no ryegrass at about 10.8 t ha^{-1}. Biomass for Bogong and Tobruk was significantly lower under ryegrass competition than with no ryegrass while there was no significant difference in biomass between triticale cultivars, with or without ryegrass present. In both ryegrass treatments, the wheat cultivar Spitfire had less biomass than the triticale cultivars and was highly susceptible to ryegrass competition (Figure 2).

DISCUSSION

Grain yield varied depending on row spacing and sowing rate, but not ryegrass presence. For crop biomass, Bogong, Tobruk and Spitfire were more sensitive to annual ryegrass pressure than KM10 and Tuckerbox. The ability to resist weed competition pressure in KM10 and Tuckerbox (10.5 and 8.5% biomass reductions) may be due to greater plant height and number of tillers (data not shown). Previous research has found that the tall short-season triticale produced the greatest crop biomass and demonstrated a high competitive ability with weeds (Beres *et al.* 2010b). Triticale cultivars performed well in production and competition with ryegrass in comparison with the tested wheat cultivar, Spitfire. There appears to be scope for utilising triticale competition in the management of weeds due to greater biomass and grain yield under crop/weed/competition conditions compared with wheat, however, the optimal agronomy may vary with the cultivar used. Lemerle *et al.* (2004) found that increasing crop sowing rate, which means crop plant population, can increase weed suppression and reduce grain yield losses due to crop competitive ability depending on environmental conditions, season, and wheat cultivars.

This experiment forms one part of a larger study. Other experiments in this study will examine the effect of crop seed size, nutrient levels and water levels on the competitive ability of triticale crop cultivars with annual ryegrass.

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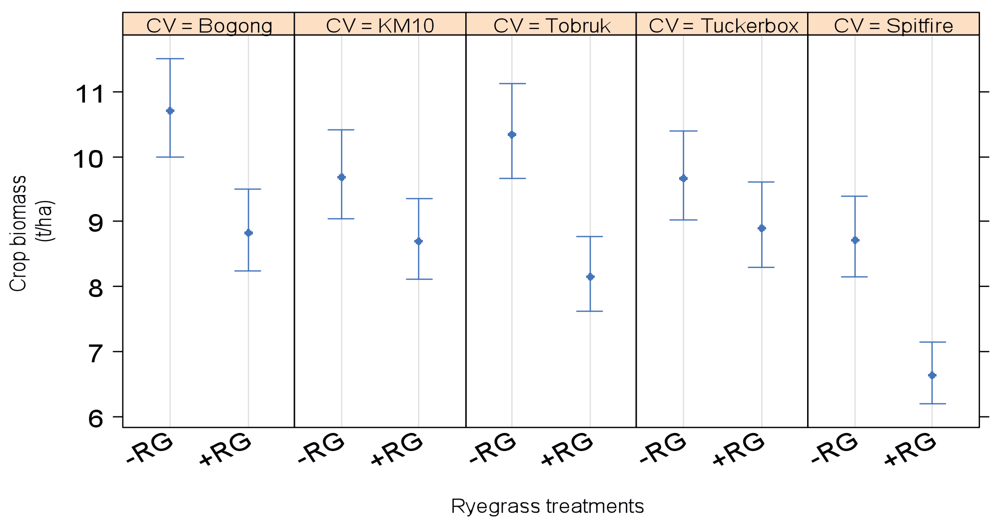

Figure 2. The effect of crop cultivar and ryegrass treatments (−RG and +RG) on the total crop biomass. The error bars show the 95% confidence intervals.

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