Wheat, barley and triticale as mimic weeds for wild oat in chickpea studies

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Summary Wheat, barley, triticale and wild oat (*Avena sterilis* L. ssp. *ludoviciana* (Dur.) Nyman) were sown to establish 'weed' densities of nil, 3, 9, 27 and 81 plants m^{-2} in chickpea experiments at Tamworth in 2002 and 2003. Yield loss in chickpea increased with weed density and was similar for each 'weed'. Triticale produced virtually the same response as wild oat in 2002. The mimic weeds and wild oat weed dry matter of 400 g m^{-2} (4 t ha^{-1}) reduced chickpea yield by at least 1 t ha^{-1}. In 2003 the yield loss relationships were again similar for the mimic weeds with barley and wheat the best mimics for wild oat. Low weed densities were more competitive with chickpea in 2003.

Using mimic weeds in competition or weed control experiments provides more uniform weed treatments than can usually be obtained by sowing actual weeds, or using naturally occurring weed populations. Using this technique means that paddocks do not become contaminated with real weeds, and volunteer weeds not wanted can be removed by spraying without compromising the experiment.

Keywords Weed competition, wild oat, mimic weeds, chickpea.

INTRODUCTION

Quantifying the cost of weeds is important in developing new cropping systems. Naturally occurring weed populations have inherent spatial variability that can make it difficult to accurately impose structured density treatments to study weed competition. Using crop plants as mimic weeds can reduce variability by allowing naturally occurring weeds to be eliminated.

'Weed-detecting' sensors that measure the ratio of near infrared/red reflectance (Felton *et al.* 1991) have been adapted to estimate differences in plant biomass using a system described as a 'Crop Canopy Analysis' (CCA) (Felton *et al.* 2002). This ratio increases proportionally to the amount of chlorophyll present in the field of view of the detectors. Sampling is programmed to record a ratio value each time the depth of the field of view of sensors move that distance across the sampling area. A continuous estimate of the crop or crop + weed canopy for the area sampled is produced.

The work reported in this paper compares wheat, triticale, and barley as 'mimic weeds' to wild oat (*Avena sterilis* L. ssp. *ludoviciana* (Dur.) Nyman), as weeds in chickpea, and if reflectance estimates early in the growing season could be related to subsequent yield loss of weedy compared with weed free treatments.

MATERIALS AND METHODS

Wheat, barley and triticale were selected as suitable mimic weeds for wild oat. The 'weeds' and Howzat chickpea were sown on 4 June 2002 and 24 May 2003 in plots 8 m long in four randomised complete blocks. Chickpea was sown in 5 × 64 cm wide rows. The wheat, triticale, barley and wild oat weed treatments were sown in six rows each 16 cm from chickpea rows 2, 3, and 4, to establish weed densities of nil, 3, 9, 27, and 81 plants m^{-2}. In 2002 the wild oats were spread by hand. In 2003, the treatments without wild oat were sprayed with 1.5 L ha^{-1} of Tristar (375 g ha^{-1} diclofop-methyl + 19.5 g ha^{-1} fenoxaprop-p-ethyl) on 16 August to eliminate naturally occurring wild oat. The established weed density and dry matter was measured by counting, cutting and removing the weeds in two 1 m^2 quadrats per plot on 16 September 2002 and 29 October 2003.

Reflectance sensors were used to estimate the amount of dry matter in each plot at several stages during the development of the crop in a non destructive sampling. The relationship between weedy and weed-free plots was investigated by calculating the ratio of crop/(crop + weed) reflectance. This ratio was used to predict the crop yield loss caused by weeds. Reflectance estimates were made 51, 62, 84, 100 and 120 days after sowing (DAS) in 2002 and 60, 96 and 110 DAS in 2003.

Chickpea yield was obtained by harvesting the centre three rows with a small plot header.

The relationship between chickpea yield and weed dry matter was analysed by a cubic spline analysis (Verbyla *et al.* 1999) and fitted using linear mixed models (Gilmour *et al.* 2002).

The yield loss in chickpea due to weeds was modelled by fitting the rectangular hyperbolic equation:

$$Y_L = iD/(1 + iD/A)$$

where Y_L is the percentage loss in yield; i is the initial slope at low weed density; D is the weed density (plants m$^{-2)}$ and A is the asymptotic yield loss (%) (Cousens 1985a,b).

RESULTS AND DISCUSSION

Establishment of the mimic weeds was quicker and more even than the wild oat. The latter tended to be in patches due to less even spreading at sowing, and/or to wild oat already in the experimental area. The density range with wild oat was less than with the mimic weeds, and none had the targeted weed density of 81 weeds m^{-2}. The mimic weeds and wild oat produced more weed dry matter in 2003 than 2002. However, there was a similar relationship for the effect of weed dry matter (Figure 1) on crop yield for both wild oat and the mimic weeds showing that the latter can be used very effectively in weed studies instead of actual weeds. Using a mimic weed with a growth habit similar to the weed species of interest can substantially reduce variability caused by volunteer weeds emerging at different stages of crop development. Selective herbicides can be used to eliminate unwanted volunteer weeds without damaging the mimic weeds.

The wheat and barley mimic weeds in 2002 were more competitive at low densities, both having i values of 6.9, whereas both triticale and wild oat had i values of 4 (Figure 2). The mimic weeds grown in 2003 were far more competitive than 2002. Barley and wild oat in 2003 had similar i values, of 52 and 50.1, respectively, and triticale and wheat slightly less competitive, with i values 19.2 and 18.6, respectively.

Of particular interest in this work is the use of crop/(crop + weed) ($1-C_0/C_w$) reflectance values in predicting crop yield loss caused by weeds. Between 80 and 100 DAS there is good separation in the reflectance values between the weedy and weed free treatments (Figure 3). The relationship between the CCA ratio and yield loss was linear in 2002 (Figure 4) and non-linear in 2003 (not shown). This may be due to the lower weed competition pressure in 2002, which was a drought year. Visual comparison of the data in Figure 4 at 62, 84 and 100 days after sowing indicates that the mimic weeds have better linear fits than the wild oat. The model fitted for the wild oats is highly leveraged by the data point corresponding to the nil weed density.

At early stages of crop development the weeds need to be of sufficient size to increase the canopy biomass compared with the crop without weeds. When the crop + weed canopy reaches a stage where there is little or no meaningful difference between the crop and weed contributions the correlation diminishes. This also relates to the leaf area ceasing to be correlated to

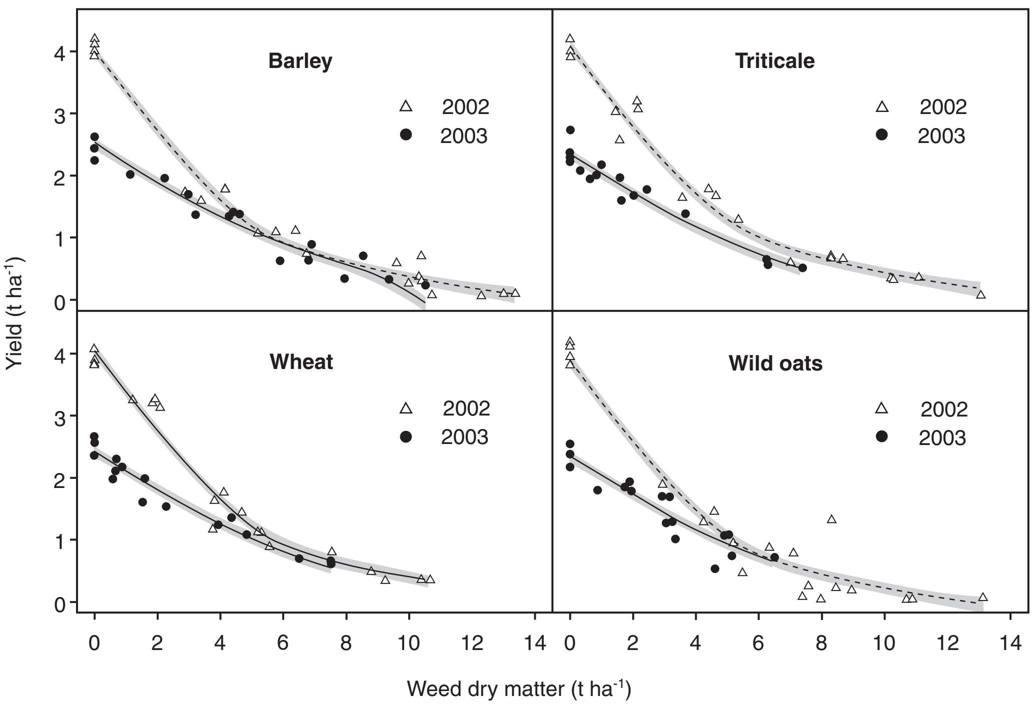

Figure 1. The effect of weed dry matter on chickpea yield. The shaded region represents a 95% confidence interval around a fitted line.

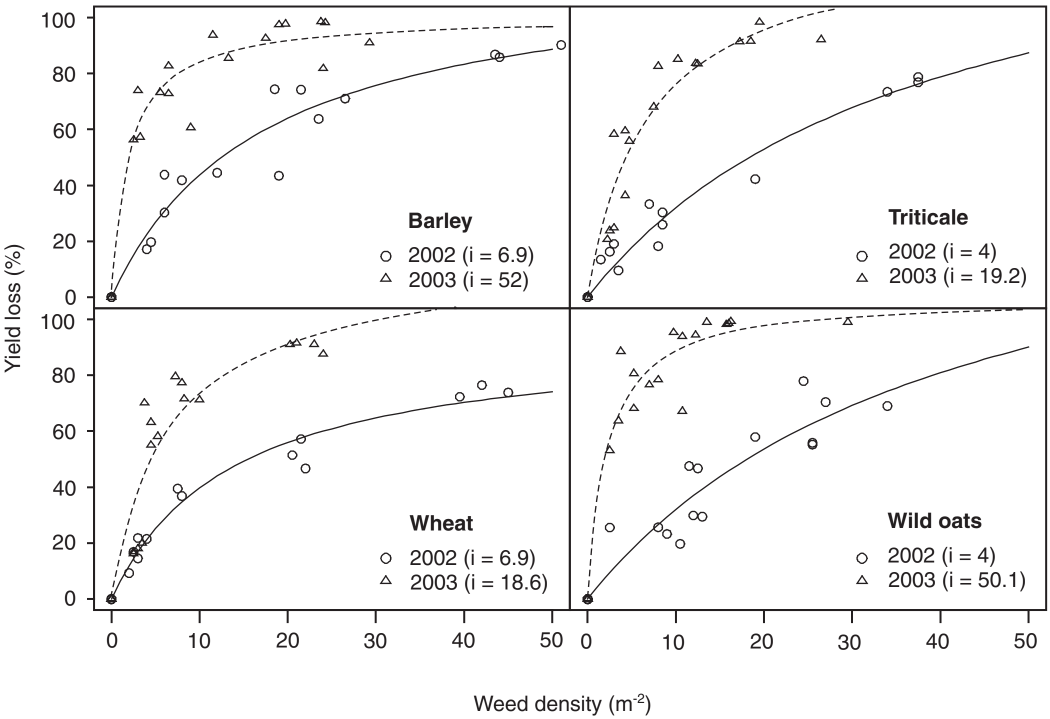

Figure 2. The effect of measured weed density on yield loss in chickpea. The line of best fit was calculated from equation 1.

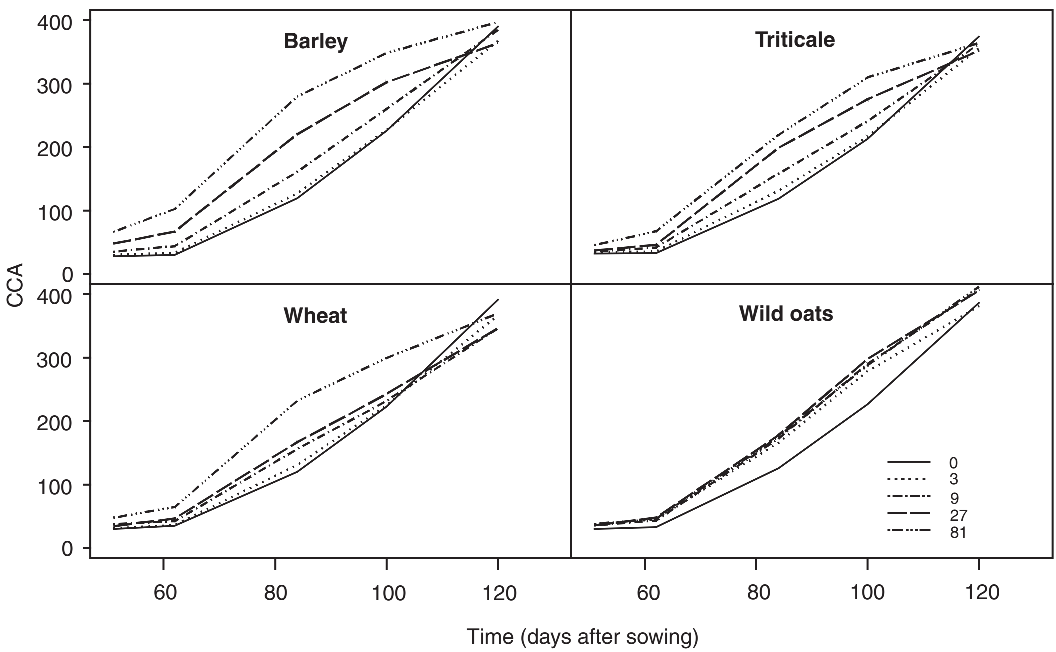

Figure 3. The reflectance values (CCA) of the chickpea and chickpea + weeds versus time for the five weed density treatments in 2002.

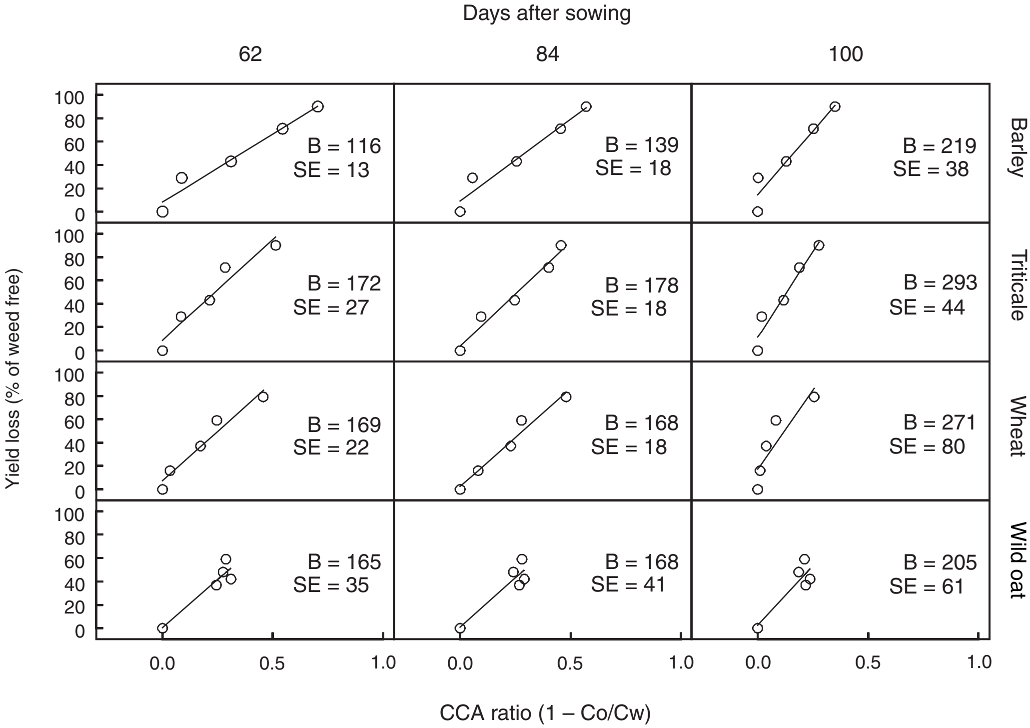

Figure 4. The relationship between percent chickpea yield loss and reflectance ratio (1−Co/Cw) at three sampling times in 2002. The rate parameter (B) and standard error (SE) are displayed and the means of each weed density treatment are plotted.

crop dry matter when the latter is more than 2000 kg ha^{-1}. The mimic weeds were all found to be an excellent substitute for wild oat in weed competition studies. Triticale was the best substitute in a low rainfall year such as 2002, while barley was the best in a higher rainfall year like 2003.

ACKNOWLEDGMENTS

We thank the Grains Research and Development Corporation for financial support for this work, and Graham Starr for his assistance with the field operations.

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