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Impact of regrowth and remnant brigalow (*Acacia harpophylla*) trees on wheat production in southern Queensland, Australia

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Abstract

The potential for integrating native brigalow (*Acacia harpophylla* F. Muell. Mimosaceae) vegetation with dryland cropping systems is being investigated in the Tara Shire, southern Queensland. Of particular interest is regrowth brigalow, a key means for landscape revegetation following broadscale land clearing last century. Integration of brigalow vegetation and cropping can result in competition for water, light and nutrients between trees and crops, and potentially, a reduction in agricultural production. Competition dynamics must be assessed to understand the trade-offs involved with brigalow-cropping integration and to guide sustainable landscape management. Extent of the brigalow-crop competition zone, i.e. the horizontal distance over which crop production is reduced, has been measured at four sites where regrowth and remnant brigalow are adjacent to wheat. Evaluated on the basis of grain yield, the competition zone ranged from 19 m for 3 year old regrowth (3YRG), to 44 m for remnant brigalow > 70 years old (> 70YRM). When expressed as a ratio of tree height, the competition zone ranged from 4 tree heights for > 70YRM to 13 tree heights for 3YRG. The tree heights results suggest that in a relative sense, regrowth brigalow produces a larger competition zone compared to remnant brigalow. Further collection of field data as well as simulation modelling will allow for investigation of the impact of land use history and seasonal conditions on brigalow-crop competition. The overall aim is to develop a simple spreadsheet model that will allow farmers to explore different brigalow-cropping scenarios and their associated economic and ecological trade-offs.

Media summary

Brigalow-crop competition is being studied in southern Queensland, to assess the potential for integrating regrowth and remnant brigalow (*Acacia harpophylla*) communities with dryland cropping systems.

Key words

Brigalow, regrowth, remnant, wheat, tree-crop competition.

Introduction

Large tracts of brigalow vegetation once covered southern Queensland. Over the last century, brigalow coverage has been reduced from approximately 7 million ha to 660 000 ha, primarily a result of land clearing for agricultural development (Environment Australia 2002). Despite significant loss of brigalow and its associated biodiversity, potential exists for biodiversity recovery, avoidance or mitigation of land degradation (e.g. salinity) and promotion of sustainable agricultural production, through the integration of brigalow regrowth and remaining brigalow remnants with conventional dryland cropping systems.

Brigalow-cropping integration is likely, however, to result in a ‘tree-crop competition zone’, i.e. an area in which crop yield is reduced due to competition for resources such as water, between the trees and adjacent crop. This zone (and also the area occupied by the trees themselves) will represent an economic cost, in terms of yield loss, to landholders. It is thus important to address the impact that brigalow-cropping integration will have on levels of production, and consequently, on farm incomes and livelihoods, in order to deal adequately with the issue of agricultural landscape sustainability.

This study will assess the extent and magnitude of brigalow-crop competition, for systems that integrate regrowth and remnant brigalow with dryland cropping, within brigalow’s range in southern Queensland, Australia. Regrowth brigalow is defined as trees that originate as suckers from residual root systems following land clearing. Remnant brigalow is defined as trees that have not been subject to clearing.

The study builds on earlier investigations by Carberry et al. (2002), who examined the effect of remnant brigalow stands on adjacent cropping. These researchers subsequently developed a simple ‘rule of thumb’, whereby the extent of the tree-crop competition zone was estimated as three times the height of adjacent trees. Carberry et al. (2002) did not investigate however, if this ‘rule of thumb’ holds for regrowth vegetation, particularly young suckers that are likely to have extensive root systems already in place, despite their short stature. Regrowth vegetation needs to be assessed as it is of particular importance in Queensland, potentially a key means for landscape revegetation.

This paper forms part of a larger integrated study that is developing a simple spreadsheet model to investigate agricultural production, salinity risk and biodiversity conservation trade-offs under different brigalow-cropping scenarios. The emphasis placed on regrowth vegetation distinguishes this work from the majority of agroforestry research conducted in Australia to date (e.g. Lefroy and Stirzaker 1999; Knight et al. 2002; Sudmeyer et al. 2002; Unkovich et al. 2003).

Methods

During the 2003 winter cropping season, sampling of wheat biomass and grain yield was done at crop maturity at four sites near the town of Tara, approximately 380 km west of Brisbane. All sites were on deep gilgaied clay soils, with cropping areas fallowed during the previous summer, and had a brigalow stand adjacent to a wheat crop. The brigalow at site 1 was three year old regrowth (3YRG); at site 2, fifteen year old regrowth (15YRG); and at sites 3 and 4, > 70 years old remnant vegetation (> 70YRM). The brigalow stands at sites 1 and 4 were orientated NW-SE, and respectively positioned on the southern and northern sides of one paddock. The stands at sites 2 and 3 were of E-W orientation and respectively positioned on the southern and northern sides of a second paddock. The rainfall total for 2003 was 588 mm, which is below median annual rainfall (677 mm) for this region (Bureau of Meteorology 2004).

Sampling for biomass and grain yield was done along six parallel transects, starting at the edge of each brigalow stand and moving out to the ‘open paddock’ (OP), i.e. the cropping area beyond the influence of adjacent brigalow. Sampling was undertaken at distances of 0 m, 4 m, 8 m, 16 m, 32 m, 64 m and OP. The latter sampling distance varied, depending on paddock configuration and brigalow stature at each site. Structural characteristics of brigalow vegetation at the start of each transect were measured and recorded.

Results

Equation 1 was used to fit curves to the field data (Figure 1). The curves show a reasonable fit, although there is some discrepancy at 16 m at sites 1, 2 and 4.

$$y = y_m - (y_m - y_0)^{-cx} \qquad (1)$$

Where:

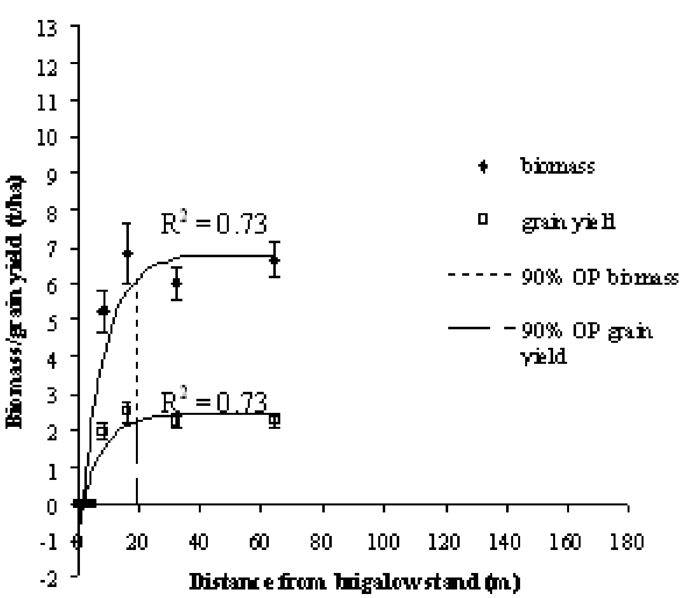
y is wheat biomass or grain yield,
y_m is maximum wheat biomass or grain yield
y_0 is minimum wheat biomass or grain yield,
c is a constant, defining the rate of increase, and
x represents distance from the brigalow stand

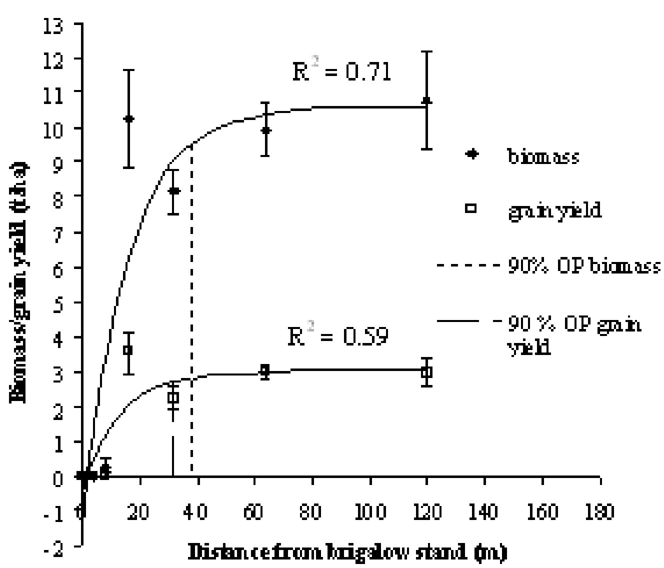
Equation 1 was also used to determine the extent of the brigalow-wheat competition zone. This zone was defined as extending up to $y = 0.9^* y_m$. Competition zone distance was calculated for wheat biomass and grain yield and expressed in metres as well as a ratio of brigalow height (Table 1). The competition zone ranged from 19 m (site 1, 3YRG) to 44 m (site 3, > 70YRM) for grain yield, and 19 m (site 1, 3YRG) to 53 m (site 3, > 70YRM) for biomass. In terms of 'tree heights' (TH), competition zone distance was least for site 4, > 70YRM (3 TH for biomass, 4 TH for grain) and greatest for site 1, 3YRG (13 TH for both biomass and grain).

The magnitude of brigalow-wheat competition was measured as percentage reduction in average grain yield in the competition zone, compared to average grain yield in the OP. Average yield in the OP was calculated by solving for y_m in Equation 1, while average yield in the competition zone was determined using equation 1 and calculating mean yield for ten equally spaced yield points between 0 m and $0.9^* y_m$. Yield reduction in the competition zone was 42% for sites 1 and 4 and 43% for sites 2 and 3 (Table 1).

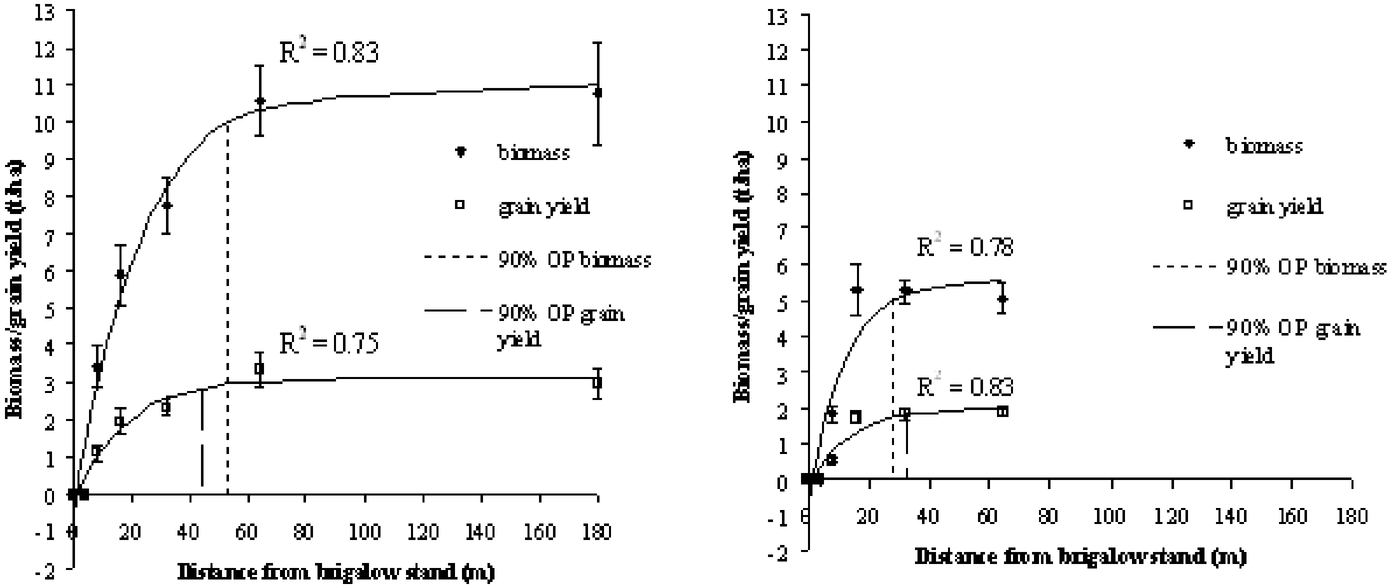
Table 1. Brigalow-wheat competition results based on wheat biomass and grain yield.

Site	Brigalow type	Av. brigalow height	Competition zones: biomass		Competition zones: grain		Yield reduction in competition zone
		m	m	TH	m	TH	%
1	3YRG	1.5	19	13	19	13	42
2	15YRG	3.8	38	10	32	8	43
3	> 70YRM	8.0	53	7	44	6	43
4	> 70YRM	9.4	28	3	33	4	42





a) b)



c) d)

Figure 1. Raw data and fitted curves for wheat biomass and grain yield at crop maturity for a) Site 1, 3YRG b) Site 2, 15YRG c) Site 3, > 70YRM and d) Site 4, > 70YRM. The standard error bars and mean data points are based on 6 reps.

Discussion

Biomass and grain yield at sites 2 and 3 were considerably higher than at sites 1 and 4. This result is due to wheat being sown 50 days earlier in the paddock where sites 2 and 3 are situated.

No relationship was apparent between brigalow age and the absolute measure of the brigalow-wheat competition zone. However, when expressed relative to the height of the trees, the competition zone generally decreased with brigalow age. This could be due to older vegetation being taller and thus providing a more favourable microclimatic environment for crop growth. The result might also be a consequence of lateral tree roots reaching their maximum extent before tree height reaches a maximum. Whatever the reasons for this relative trend, it suggests that the competitive nature of regrowth vegetation should not be underestimated when considering integration with dryland cropping systems.

Tree heights results for both regrowth and remnant brigalow do not show strong support for the Carberry et al. (2002) ‘rule of thumb’, whereby the competition zone is approximately three tree heights. It is likely that different land management and vegetation disturbance histories will impact differently on the development of brigalow as well as the extent and activity of its residual root systems. Variable patterns in tree growth and brigalow-crop competition could mean a relationship between tree height and the extent of the competition zone is not well defined. Furthermore, a simple linear relationship may not be realistic, given there are additional factors that potentially influence brigalow-crop competition (e. g. brigalow density, brigalow leaf area index). A multiple regression approach that accounts for a number of key variables might be a better predictor of the extent of the brigalow-crop competition zone.

The magnitude of brigalow-wheat competition, based on calculation of percentage yield reduction in the competition zone, was almost identical across the four sites. This is a likely artefact of the curve-fitting method. It suggests that extent of competition, rather than magnitude of competition, is a more informative indicator of brigalow-crop interaction. Nonetheless, it is interesting that the same curve-type suited the data at all sites.

Conclusions

To calculate the impact of brigalow vegetation on crop production on a whole-of-property basis, key factors that need to be considered include brigalow stand age, dimensions and structure; paddock dimensions and land and vegetation management history. Seasonal conditions are also likely to influence brigalow-crop competition and are thus an important factor for calculating long-term average impact.

A complete assessment of the potential for brigalow-cropping systems in southern Queensland should extend to a range of relevant soil types, crop species and brigalow regrowth of various ages. While this study is restricted to a single soil type, a single crop and a limited number of sites, it will, nonetheless, contribute to the development of a brigalow-cropping scenario model. This scenario model will be based on simple 'rules of thumb' derived from the field data reported here, as well as future field data collection and simulation modelling. The scenario model will not only address production aspects of brigalow-cropping integration but also broader landscape issues such as salinity risk and biodiversity conservation.

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