Pasture cropping sensitivity analysis: Selecting crop and pasture species, and management practices for Western Australia

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Abstract
Pasture cropping with tropical grasses has shown promise for several regions in the WA wheat belt. In this research, we modelled the crop yield, pasture yield, and total production for barley and canola crops grown either as monocultures or with kikuyu or Gatton panic, for 5 location in WA. Pasture suppression efficacy was modelled at either 90 or 98%. Kikuyu was particularly competitive, and appears less suitable for pasture cropping than Gatton panic. For barley sown into Gatton panic pasture, yield penalties were generally small, but results were more variable for canola.

Keywords
Mixed farming, Evercrop, crop rotation.

Introduction
Previous research has shown that the practice of sowing annual winter crops into established stands of summer active perennial grasses, or pasture cropping, is most likely to be successful where climates are favourable (Lawes et al. 2014; Ward et al. 2014). In the grain growing regions of Western Australia, a whole-farm modelling study found that pasture cropping is likely to be risky due to low winter rainfall or high winter temperatures (Thomas et al. 2014). The study also found that there are further opportunities for both strategic and tactical management of pasture cropping, specific to farm location, which should be explored. The aim of this study was to further investigate the importance of selection of crop and perennial grass species, and associated management of inter-plant competitive interactions for areas that are considered to be suited to pasture cropping in Western Australia (i.e. deep sandy soils, higher winter rainfall, longer growing season and cooler winter temperatures).

Methods
A sensitivity analysis of the relative productivity of crops and pastures grown as pasture cropping versus monoculture stands was conducted for 5 locations in Western Australia using the AusFarm® model. The locations, selected as those likely to have climates and soils suitable for pasture cropping, were: Moora (average annual rainfall 450 mm, average April-October rainfall 375 mm), Arthur River (447 mm, 351 mm), Wellstead (610 mm, 438 mm), Bremer Bay (630 mm, 478 mm) and Condingup (548 mm, 401 mm). A deep sandy soil to a depth of 3.0 m, with a water holding capacity of 109 mm, was used for all simulations. The pasture systems and tactics for managing the crops and pastures were described using rule-based coding in the AusFarm® biophysical model (Thomas et al. 2014). Perennial grasses Gatton panic (*Panicum maximum* cv. Gatton) and kikuyu (*Pennisetum clandestinum*) pastures, were parameterised and validated in other studies (Descheemaeker et al. 2014; Thomas et al. 2012). The perennial grasses were established in pasture monoculture and pasture cropping paddocks, sown on September 26 during the first year of the simulation run. Both monoculture and pasture cropped pastures were cut annually each March to 100 mm height to simulate grazing. Winter crops of barley cv. Buloke or canola cv. Hyola were sown into the established perennial grass pastures as described by Thomas et al. (2014). In this study, two levels of perennial grass suppression (simulating herbicide application) were used at seeding, either 90% or 98% efficacy. This enabled a 2 perennial grass species x 2 winter crop species x 2 suppression efficacy factorial modelling structure. Paddock scale crop and pasture model simulations were run from 1962 – 2014, with the first 3 years of data excluded to allow model conditions to initialise. Historical weather data for these sites were obtained as Patched Point Datasets from the SILO database (http://www.longpaddock.qld.gov.au/silo).

Results
At different sites different trade-offs existed in relative crop and pasture productivity. At Arthur River and Cranbrook, crop yields were preserved but inhibition of perennial grass growth was the highest (Figures 1

and 2), whereas for Condingup, Moora and Wellstead, winter crop yield penalties were higher but pasture production was maintained or even increased. Specifically, at Moora and Condingup, both kikuyu and panic yields were higher in the pasture cropping system, presumably associated with increased nitrogen. Impacts on crop yields were also highest for these sites.

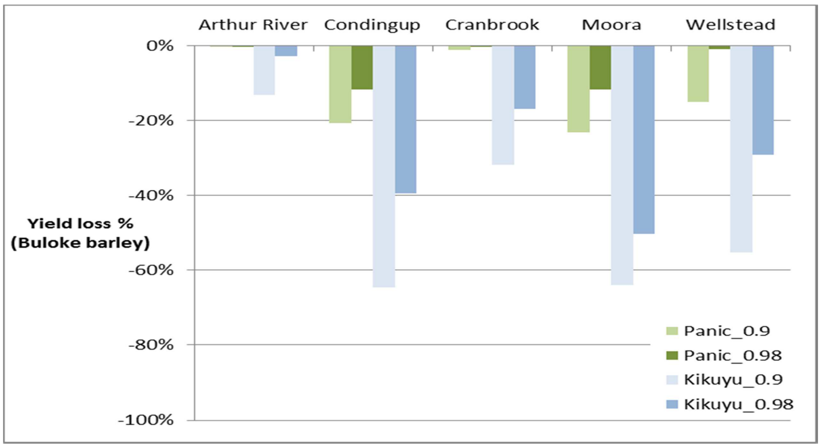

Figure 1. Grain yield loss (%) in barley associated with pasture cropping (compared with monoculture) for Gatton panic and kikuyu perennial grasses with 90% and 98% suppression of the grasses prior to crop seeding.

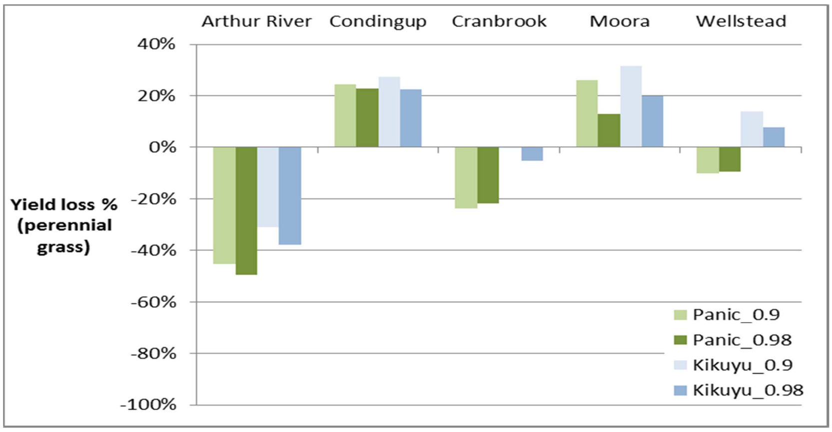

Figure 2. Pasture yield loss (%) associated with pasture cropping with barley (compared with monoculture pasture) for Gatton panic and kikuyu perennial grasses with 90% and 98% suppression of the grasses prior to crop seeding.

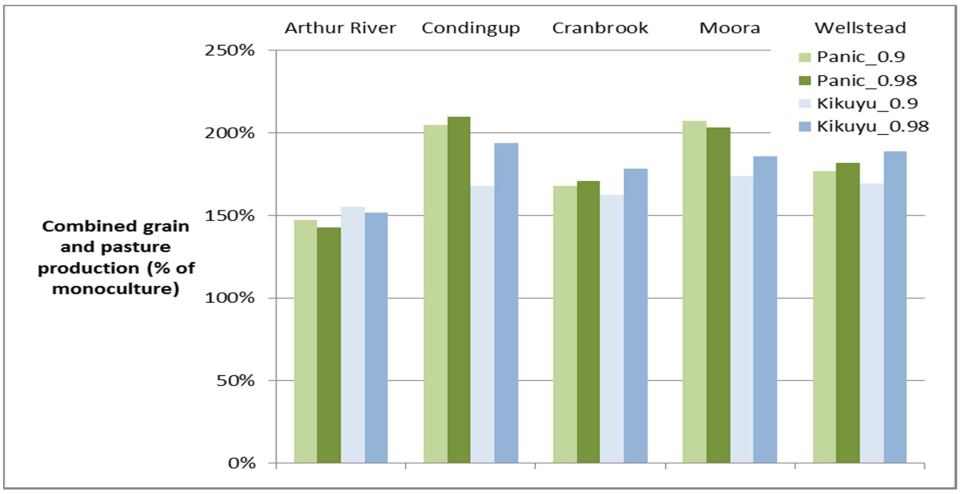

Figure 3. Combined average grain and pasture yield (average % of monoculture yields) associated with pasture cropping for Gatton panic and kikuyu perennial grasses with 90% and 98% suppression of the grasses prior to crop seeding.

Kikuyu was particularly competitive with the barley, with yield penalties exceeding 20% for 3 of the sites for the 98% grass suppression scenario, whereas the yield penalty was less than 15% for all sites for barley grown with panic with 98% suppression. Our combined crop and pasture productivity assessment shows that the overall success of pasture-cropping varies with site. At Arthur River, Cranbrook and Wellstead, overall crop and pasture productivity was similar for kikuyu and panic (Figure 3). However, at Moora and Condingup, the yield penalty for combined crop and pasture production was greater with kikuyu than Gatton panic. This was due to large barley yield penalties from kikuyu competition at these locations (Figure 1). At all sites, combined production of the pasture-cropped treatments was considerably greater than monoculture production for an equivalent land area, illustrating the increased total production associated with pasture cropping systems (Figure 3).

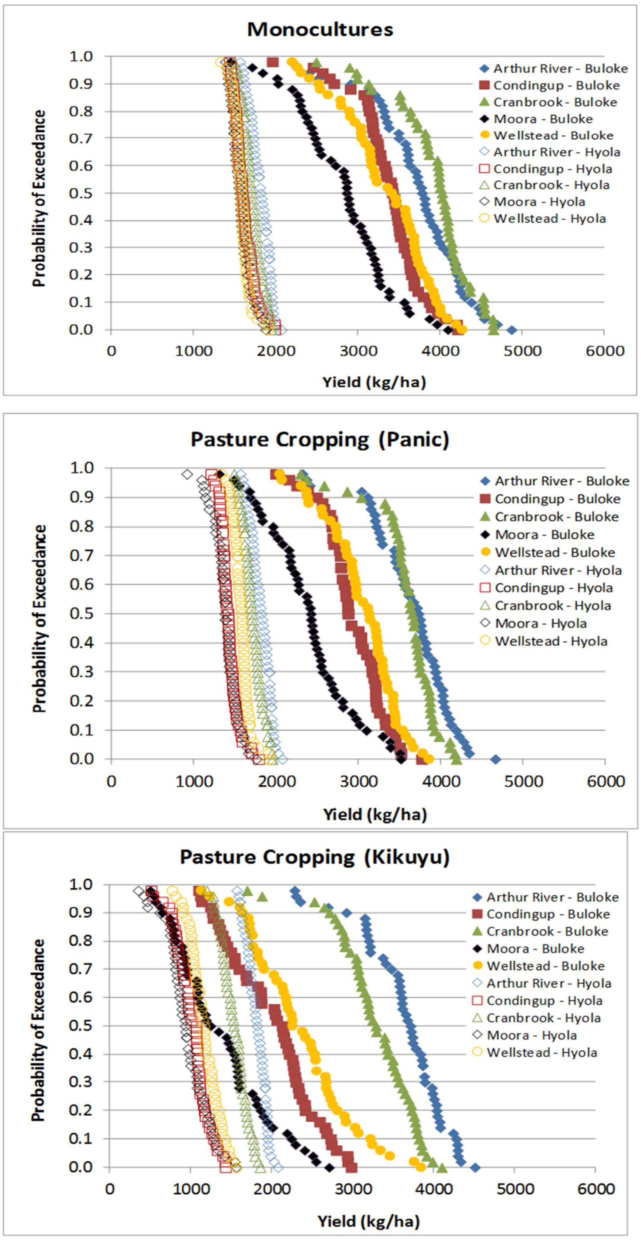

Figure 4. Simulated probability of exceedance distributions of the yield of wheat cv Buloke and canola cv Hyola grown as a monoculture (a), or in a pasture cropping system with Gatton panic (b) or kikuyu (c) at Arthur River, Condingup, Cranbrook, Moora and Wellstead in Western Australia.

Variability in the distribution of barley yield both within and between sites was greater than canola, with the yield of canola less responsive to variability in seasonal conditions (Figure 4a). Consistent with the previous results, the probability of exceedance distributions show crop yield reductions (particularly for barley) in the Gatton panic grass pasture cropping system, compared with the monoculture (Figure 4b). However, in the kikuyu pasture cropping system there are marked yield reductions in both barley and canola crops, and differences associated with location, although relative differences for the crops was consistent among locations (Figure 4c).

Discussion

Pasture cropping systems provide the opportunity to improve total productivity on agricultural land, by increasing plant biomass production across the season. In our modelling study, increases greater than 150% were consistently found in the pasture cropping system compared with an equivalent area of crop and pasture. Higher perennial grass production in some pasture cropping systems, compared with monoculture perennial grass swards, highlights synergies that may exist through the capture and retention of nutrients applied during the cropping phase. This has advantages for both productivity and natural resource management. The relative cost of reduced crop yields will likely be higher than reduced perennial grass growth in a pasture cropping system, however the optimal balance of these will also depend on climate and this investigation is amenable to a whole farm system analysis.

Our study supports other findings that in many cases pasture cropping systems will result in crop yield penalties that make the system unviable. However, in our modelling study the suppression of grasses with herbicide could effectively manage crop-grass competition. Kikuyu generally produced more biomass, and competed more aggressively with crops, compared with Gatton panic. The suppression strategy for kikuyu was only successful at one location (Arthur River). Yield penalties were either negligible (Arthur river, Cranbrook and Wellstead) or small (Condingup and Moora) for barley sown into Gatton panic pasture, and where the highest suppression rate was applied to the panic grass at seeding. Canola yields were low, and less responsive to season than expected. Further testing of the canola model against field data for the regions evaluated is warranted.

This study shows that the overall productivity of crops and pastures in pasture cropping systems for particular regions will depend on the crop and pasture species selected, and the management of nutrients and interplant competition.

Acknowledgements

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