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Experimental trials and simulation modelling indicate that summer-growing perennial grasses are a potential new feed source in the Mallee region of southern Australia

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Abstract. In the Mallee region of southern Australia, the dry and variable climate results in frequent summer-autumn feed gaps, restricting the profitability of farms that combine livestock and crop enterprises. To assess the suitability of summer-growing perennial grasses to fill these feed gaps, 2 replicated field trials with different cultivars were conducted. The data also served to validate a C4 grass model, which was then used in a simulation experiment comparing 2 different soil types and 3 locations. Most grass cultivars established well except on sandy, non-wetting soils. Four out of 5 cultivars persisted over 6 years, producing 1000 – 9000 kg/ha in response to summer rainfall, with little differences between the cultivars. Model performance was satisfactory (R^2 : 0.82-0.93; RMSD: 476-1673 kg/ha, depending on cultivar). Simulation results indicated that biomass production closely followed seasonal trends in temperature and moisture availability. Grazing potential in 3 locations was highest in summer and early autumn, with differences according to rainfall and soil type. It was concluded that summer-growing perennials are a promising option to alleviate feed gaps on mixed crop-livestock farms.

Keywords: APSIM-GRAZPLAN model, cereal-sheep systems, erosion control, on-farm trials.

Introduction

The Mallee agro-ecological zone in south-eastern Australia is characterized by a Mediterranean climate with low annual rainfall. The dominant dryland farming system combines wheat and barley in rotation with volunteer medic-based pastures that are primarily grazed by sheep. Regular feed gaps over summer and autumn (Moore *et al.* 2009) are commonly met by feed supplementation, which limits farm profitability (Robertson 2006). Besides alleviating feed gaps, summer-growing perennials have potential to also reduce high erosion risk in summer-autumn, increase the production from marginal cropping soils, reduce the risk of rising water tables, salinity and acidity, and be used as a basis for pasture cropping using inter-sown winter crops (Finlayson *et al.* 2012). First evidence that summer-growing grasses can grow and persist in Mediterranean climates in Australia came from Western Australia (WA) (Moore *et al.* 2006), where over 50,000 ha have been established on mostly marginal sandy soils of the medium-low rainfall zone (G. Moore, pers. comm.). However, soil and climate differences prevent a simple transfer of the WA results to the Mallee. This study reports on the first on-farm trials with promising grass species in the Mallee. Complementary to trial results, pasture simulation models are a useful tool

to assess long-term biomass production and grazing potential over a range of soils and climates. The APSIM-GRAZPLAN model is widely applicable to several Australian pastures (Donnelly *et al.* 2002), but its perennial C4 grass module has not been tested with experimental data from low rainfall regions.

The objectives of this study were to: (1) assess the trial performance of summer-growing perennial grasses in the Mallee region; (2) evaluate the APSIM-GRAZPLAN model in simulating biomass production of a perennial C4 grass; and (3) explore the timing of feed production and the grazing potential of perennial summer-growing grasses under typical climate and soil conditions of the Mallee.

Methods

Trials

A replicated on-farm trial was established in November 2006 at Hopetoun on a sandy loam with clay at depth (0.7 m) and in October 2010 at Karoonda on a sandy clay loam with a coarse sandy topsoil. Both sites have similar average annual rainfall of about 340 mm, with the average summer rainfall (October to April) being 148 and 133 mm in Hopetoun and Karoonda, respectively. Species selection (Table 1) was based on results from WA (Moore *et al.* 2006) and a species audit (Pengelly

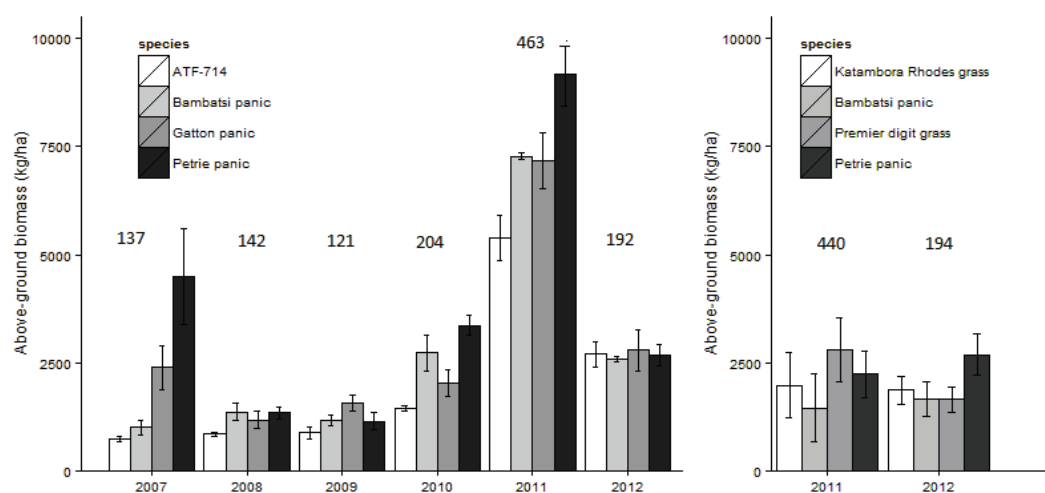
Table 1. Grass cultivars used in the trials with range of average plant numbers (plants/m²) one year after sowing

Hopetoun (March 2007)	Plant no	Karoonda (April 2011)	Plant no
<i>Megathyrsus maximus</i> (Jacq.) cv. Petrie panic	31-44	<i>Megathyrsus maximus</i> Jacq. cv. Petrie panic	3-8
<i>Panicum coloratum</i> L. cv. Bambatsi panic	31-37	<i>Panicum coloratum</i> L. cv. Bambatsi panic	1-6
<i>Megathyrsus maximus</i> Jacq. cv. Gatton panic	25-36	<i>Chloris gayana</i> Kunth cv. Katambora Rhodes grass	22-36
<i>Panicum coloratum</i> L. cv. ATF-714	30-40	<i>Digitaria eriantha</i> Steud. cv. Premier digit grass	1-4
<i>Digitaria milanjiana</i> (Rendle) Stapf cv. Strickland finger grass	34-48	<i>Setaria incrassata</i> (Hochst.) Hack. cv. Inverell purple pigeon grass	Failed to establish

Table 2. Model settings for the simulation study of grazing potential

Location	Annual rainfall (mm)	Summer (Oct-Apr) rainfall (mm)		PAWC (mm) *	Rooting depth (m)	Organic C stock (kg/ha)
Waikerie	258	148	High potential soil	140	1.4	133
Hopetoun	342	176	Low potential soil	63	0.6	38
Charlton	403	225				

*PAWC = plant available water capacity

**Figure 1. Average above-ground biomass in February-April at Hopetoun (left) and Karoonda (right) with preceding summer (Oct-Apr) rainfall (numbers). Error bars indicate standard errors.**

et al. 2006). Two sowing rates (3 and 6 kg/ha) were compared at Hopetoun, but as no difference was found between them, one sowing rate of 5 kg/ha was used at Karoonda. At sowing a knockdown herbicide and basal fertilizer (6 kg/ha N (Granulock Supreme Z) at Hopetoun and 9 kg/ha N (DAP) at Karoonda) were applied. The Hopetoun trial received 25 kg/ha of N (urea) again in September 2009 and January 2011. Grasses were mowed every year in May-June. Plant numbers were recorded and standing biomass cut and removed from quadrats at regular intervals.

Model validation and simulation of grazing potential

The Hopetoun standing biomass data for the 4 panic cultivars was used to validate the APSIM-GRAZPLAN model. The model was run from 1 November 2006 to 10 May 2012 using SILO climate data for Hopetoun (www.longpaddock.qld.gov.au/silo) and initial soil conditions, derived from soil analysis. Pasture management operations, such as sowing, mowing and fertilizer application, were replicated in the simulations. After validation, a simulation experiment was run using 60

years (1950-2010) of climate data for 3 locations on high and low potential soils typical of the Mallee region (Table 2). The probability of being able to graze the pasture was assessed using a threshold of 1000 kg/ha green biomass and a minimum dry matter digestibility of 50%. Stocking density was assumed to be 10 dry sheep equivalents (50 kg) per ha.

Results

At Hopetoun, plant density was 25-44 plants/ha one year after sowing (Table 1). Pasture establishment in Karoonda was more variable, due to the non-wetting surface soil. Sowing rate at Hopetoun did not have an effect on plant numbers or biomass production. Grass biomass production in Hopetoun was strongly related to summer rainfall, with small differences between cultivars (Fig. 1).

Only ATF-714 produced significantly less than the other cultivars in most of the years. Unlike Hopetoun, biomass production at Karoonda did not reach high levels following the wet 2010-11 summer. This is explained by the later, and in some places, poor establishment in 2010. Biomass production was not

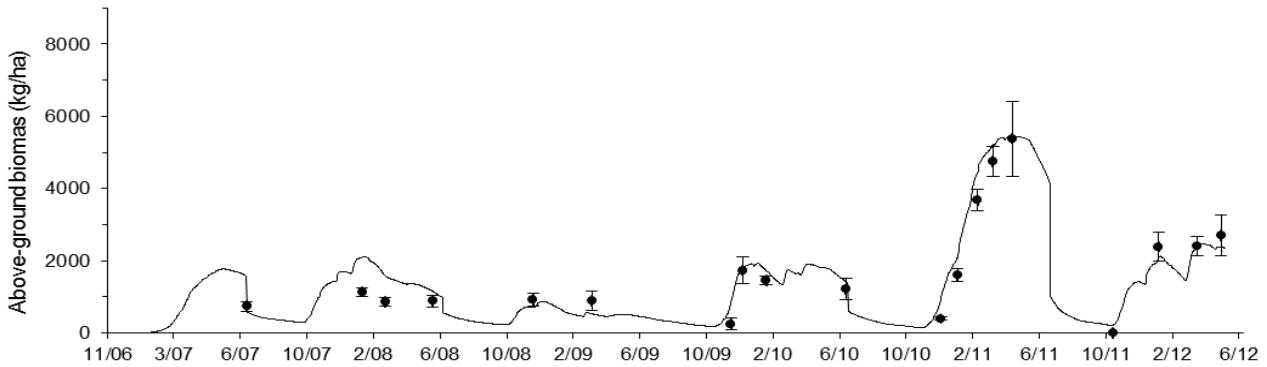


Figure 2. Observed (dots, with 95% confidence interval) and simulated (line) above-ground biomass for the ATF-714 cultivar in Hopetoun 2007-2012

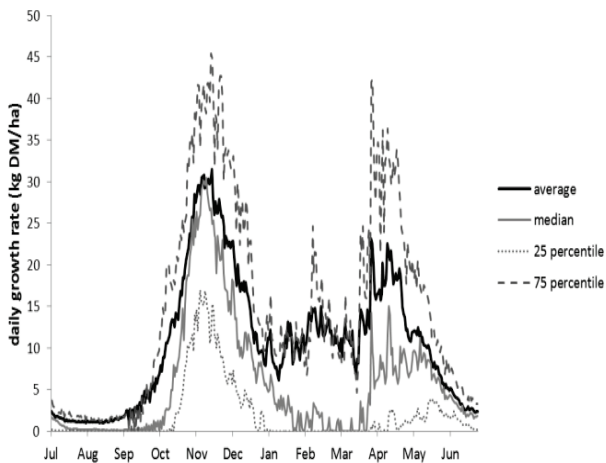


Figure 3. Simulated daily growth rates for summer-growing perennial pastures on a high potential soil in Hopetoun using climate data from 1950-2010

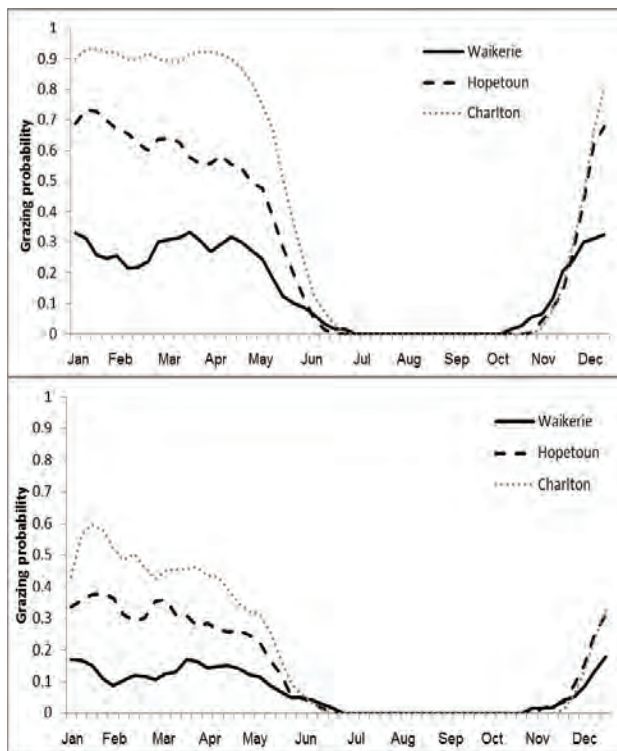


Figure 4. Probability of being able to graze a summer-growing perennial grass pasture for three locations and a high (top) and low (bottom) potential soil

Table 3. Model performance statistics for the 4 cultivars and the cultivar data pooled together (last column)

	Gatton panic	Petrie panic	Bambatsi panic	ATF-714	all cultivars
R ²	0.91	0.85	0.91	0.93	0.82
RMSD* (kg/ha)	776	1673	880	476	1049

RMSD (Root mean square deviation)

different between cultivars. Even though above-ground biomass production was similar, the stoloniferous growth pattern of Rhodes grass was distinct from the erect growth of the other grasses. Plant numbers stabilized at between 4 (Petrie) and 10 (ATF-714) plants/m² in Hopetoun and between 4 (Premier) and 25 (Katambora) plants/m² in Karoonda after two years.

Model validation and simulation of grazing potential

The model predicted pasture biomass production of the four cultivars well, with model predictions closest to production by ATF-714 (Table 3; Fig. 2). For the other cultivars, the 2011 biomass production following the very wet 2010-11 summer was under-estimated by the model.

Long-term model simulations indicate that biomass production closely follows seasonal trends in temperature and moisture availability (Fig. 3). Biomass production is high in spring and autumn when both temperature and the probability of having adequate soil moisture are high. In summer growth is often limited by moisture stress, whereas winter growth is limited by low temperatures. The grazing probability rises in December and remains high through to April, with clear differences between locations and soils (Fig. 4). On low potential soils the grazing potential is roughly half of that of high potential soils, whereas differences in grazing probabilities between locations relate to rainfall amount and timing. Across the 3 sites, potential grazing days varied from 56-155 and 26-73 days per year on a high and low potential soil, respectively. A lower green biomass threshold of 500 kg/ha, however, would result in a higher grazing potential of 113-191 and 74-141 days on a high and low potential soil, respectively.

Conclusion

The trial at Hopetoun showed that 4 panic grass cultivars persisted for at least 6 years, indicating that pasture establishment costs would be worthwhile. In years with average rainfall, summer biomass production amounted to 1000-2000 kg/ha for most cultivars, whereas in wet years, biomass production peaked at 9000 kg/ha. The APSIM-GRAZPLAN model simulated biomass production well. The model revealed the likelihood of high growth rates, especially in November to April, in response to high temperature and adequate soil moisture conditions. Average grazing probabilities at locations with ≥ 300 mm of annual rainfall are above 50% from December to April on high potential soils. Even on low potential soils with a conservative minimum green biomass threshold (1000 kg/ha), grazing is possible for on average 2 months in these locations. However, where annual rainfall is ≤ 250 mm, summer active grasses are not a reliable feed source. We conclude that summer-growing perennial grasses have the potential to reduce feed shortages in the Mallee especially in: (1) early summer around the time of cereal harvesting, when annual pastures have dried off and cereal stubble have not yet become available; and (2) autumn, when annual pastures have not yet produced enough biomass.

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