An economic analysis of perennial cereal crops in Australia

Lindsay Bell[1,2,3], Felicity Byrne[1], Mike Ewing[1] and Len Wade[1,2,4]

[1]CRC for Plant-based Management of Dryland Salinity, 35 Stirling Highway, Nedlands WA 6009
[2]School of Plant Biology M084, The University of Western Australia, 35 Stirling Highway, Nedlands WA 6009
[3] CSIRO Sustainable Ecosystems/APSRU, PO Box 102, Toowoomba Qld 4350
[4] Charles Sturt University, E.H. Graham Centre for Agricultural Innovation, Locked Bag 588, Wagga Wagga NSW 2678

Abstract
Interest in the possibility of perennial grain crops in Australia is increasing because of the sustainability benefits they could provide. This desktop study aimed to investigate how the economics of a system using perennial cereals might compare to an annual dryland cropping systems in a region of southern Western Australia. Perennial grain crops could provide some input savings for fertiliser, herbicides, tillage and sowing costs but are also likely to have lower yields than annual crops. If an equivalent grain price was received, a perennial cereal for grain production purposes only would need to yield between 60 and 75% of annual wheat to be more profitable on soil types where annual wheat profitability is low. Lower yields could be acceptable for a premium priced product. However, if grain was only suitable for lower price markets (e.g. feed grain receiving $30/t less) then the minimum yield required is > 85% of annual wheat. Alternatively, a dual-purpose perennial grain crop that also provides additional green feed particularly at the beginning of the growing season could greatly increase whole-farm profitability through increased livestock production. A perennial cereal that could provide 800kg DM of additional green feed between harvest and early winter would be selected in a farm plan that maximises profitability even when it receives $30 less per tonne and yields only 40% of annual wheat. This indicates that forage qualities, growth pattern and grazing tolerance of a perennial cereal could be important characteristics to offset lower grain yield and quality than annual cereals.

Key Words
Dual-purpose, wheat, profitability, MIDAS, whole-farm

Introduction
Introducing perennial plants into annual cropping systems can greatly improve their sustainability by reducing drainage of water and nutrients, improving or maintaining soil quality and protecting soil from erosion (Silburn et al. 2007; Ward 2006; Pannell and Ridley 2005). Development of perennial grain crops could have a wide range of environmental benefits while also satisfying the need to produce food. Perennial grains might be developed from either domestication of wild species with potential or hybridization of currently grown crops with perennial relatives (Cox *et al.* 2002; Davies *et al*. 2005). Some progress towards breeding perennial crops has been made in the USA, but in Australia efforts have been limited. While perennial crops are anticipated to have cost savings such as reduced tillage, the relative profitability of perennial grain crops compared to traditional annual systems will greatly affect their attractiveness to farmers and the scale of adoption that could be achieved. This study aimed to investigate how the economics of a perennial cereal might compare to dryland wheat-based cropping systems in the western Australian grains-belt. This was based on speculations on how a perennial cereal might perform relative to annual wheat. For a more thorough account of this analysis refer to Bell *et al.* (2008).

Methods
This analysis was conducted using the central wheat-belt version of MIDAS (Model of an Integrated Dryland Agricultural System), which represents a typical dryland farm in this region of Western Australia (for more details refer to Kingwell & Pannell 1987). MIDAS is a steady state, whole-farm bio-economic model that optimises farm profitability subject to managerial, resource and environmental constraints. To the existing rotations contained in the model; 5 new rotations which include perennial cereal were added. Base scenarios were based on the following assumptions: a perennial cereal would yield less than annual wheat and was assumed to yield 60% of annual wheat on all soil types; grain quality and price would be $35 below milling wheat, similar to a feed grain; but pre-sowing pesticide, seed and sowing costs would only be incurred in the first year; and, less fertiliser would be required due to the lower removal of nutrients in grain yield and greater capacity of a perennial plant to capture and recycle nutrients (Table 1). The potential of a perennial cereal that provides dual-purpose grazing over summer and early autumn was also considered. In addition to similar stubble yield and quality from annual wheat, extra green forage (10.75 MJ/kg) after harvest and early

in the growing season (based on a growth rate of 25 kg DM per day from 10 May–13 June) was made available for grazing with no detriment to grain yield.

A sensitivity analysis was conducted with varied assumptions of grain yield, grain price, and the amount and timing of forage availability to determine the importance of these aspects, and critical levels relative to annual wheat that would need to be obtained to make perennial wheat equally profitable.

Table 1. A comparison of assumed variable input costs (AU$/ha) for annual wheat and first and subsequent years of a perennial cereal in the medium rainfall central wheat-belt version of MIDAS.

		Perennial cereal	
Costs	Annual wheat	Year 1	Year 2 onwards
Fertiliser	90	45	45
Pesticides	37	37	18
Seeding	24	24	-
Seed	10	10	-
Harvesting	29	29	29
Insurance	2	1	1
Seed cleaning	3	2	2
TOTAL	195	148	95

Results

Perennial cereal for grain only

Under base assumptions a perennial cereal for grain only was not sufficiently profitable to be selected in the optimal farm plan. Perennial cereal rotations were between $25 and $120 per year less profitable than the best alternative, but the difference was less on soils where annual wheat is less profitable (e.g. poor sands, shallow duplex and sandy surfaced valley soils). It was evident that if a perennial grain price is > $30/t lower than annual wheat then grain yields would have to nearly match or exceed annual wheat to be equally profitable (Table 2). However, if equal or premium prices were obtained for a perennial grain then profitable grain yields are substantially lower than annual wheat and may be achievable.

Table 2. Relative perennial wheat yield (% of annual wheat) required to be equally profitable to existing best option on each soil type at various grain price differentials, when additional forage grazing was not included.

Soil type	Grain price differential between annual wheat and a perennial grain ($/t)				
	-45	-30	-15	0	+15
1. Poor sand	130%	126%	105%	70%	61%
2. Average sandplain	105%	100%	85%	75%	60%
3. Good sandplain	115%	110%	95%	85%	75%
4. Shallow duplex soil	95%	90%	70%	65%	55%
5. Medium heavy soil	140%	135%	115%	100%	90%
6. Valley floor soil	100%	95%	80%	75%	60%
7. Sandy surfaced valley soil	95%	85%	75%	60%	55%
8. Deep duplex soil	95%	90%	80%	70%	65%

Dual-purpose perennial cereal

Additional forage that might be produced by a perennial cereal greatly improved its attractiveness (base assumption of 1.5 t DM/ha provided 5 Dec – 13 Jun) and meant that it was included on 20% of the farm in the optimal plan and greatly increased farm profit by 42% ($21/ha) (Table 3). Perennial cereal replaced the less profitable wheat-lupin rotation on the shallow duplex and sandy-surfaced valley soils. Including a dual-purpose perennial cereal increased the number of sheep that could be supported, increasing stocking rate by 1.3 dse/ha without increasing the supplementary feed required (Table 3). Perennial wheat reduced grazing stubbles in early autumn and after the break of season reduced the amount of grain supplement required. This supplement could be then be used to defer grazing of other pastures until later in the season. The area of pasture also increased to support the additional sheep during winter and spring.

Table 3. Comparison of farm profitability, allocation of land to crop and pasture, and livestock numbers and supplementation under an optimal farm plan with and without the integration of a dual-purpose perennial grain (DPG).

Scenario	Farm profit (AU$'000)	Profit (AU$/ha)	Perennial wheat (ha)	Crop area (ha)	Pasture area (ha)	Sheep numbers (dse)	Stocking rate (dse/ha)	Supplementary feed (kg/dse)
Without DPG	111.2	55.6	0	1,100	900	6,815	7.6	59.4
With DPG	152.9	76.5	400	900	1,100	9,795	8.9	58.4
Change	+41.8	+20.9	+400	-200	+200	+2,980	+1.3	-1

While a perennial cereal appears to have the have potential to grow additional green forage during early summer and in autumn, early in the growing season, there is uncertainty about the amount. Table 4 shows that less additional feed was provided by a perennial cereal, its proportion in an optimal farm plan is also reduced. Nonetheless, even when relatively small amounts of additional feed were assumed to be available, particularly after the season break (170 kg DM/ha), a perennial cereal was still profitable on >10% of the farm. The ability of perennial wheat to produce feed early after the season break is a key factor that will affect its profitability

Table 4. Effect of time and amount of additional forage produced by a perennial cereal on the % of farm allocated to a perennial cereal in the optimal farm plan.

% of starting assumptions	Both before and after break of season (5 Dec - 13 Jun)		Only after season break (10 May to 13 Jun)		Between harvest & season break (5 Dec to 9 May)	
	Forage produced (kg DM/ha)	% of farm area	Forage produced (kg DM/ha)	% of farm area	Forage produced (kg DM/ha)	% of farm area
100	1560	20	675	12	885	11
75	1170	16	506	10	664	13
50	780	13	338	13	443	0
25	390	11	170	11	221	0

The potential for additional forage from a perennial grain crop also reduces the yield required for it to increase farm profitability. Table 5 shows that even at grain yields of 40% of annual wheat, a dual-purpose perennial cereal that could provide an additional 780 kg of forage can still provide economic benefits to mixed farmers and is included on 12% of the farm area. This demonstrates that there is capacity to trade-off grain yield for forage production from a perennial cereal.

Table 5. Effect of amount of additional forage provided and grain yield relative to annual wheat on the area of perennial cereal (% of farm) that would maximise farm profitability.

Additional green forage available (kg DM/ha)	Yield for perennial grain as % of annual wheat		
	60%	50%	40%
1560	20%	19%	14%
1170	16%	16%	14%
780	13%	13%	12%
390	11%	0%	0%

Conclusion

This economic analysis suggests that the development of a dual-purpose perennial cereal for Australian cropping systems has significant merit, particularly with escalating input costs and social pressure for more sustainable food production systems. Importantly, some considerations were not included in the study such as how a perennial grain would compete with other emerging technologies such as perennial pastures which also provide forage during summer and autumn. Despite this, the analysis has important biological and breeding implications. Firstly, a perennial cereal crop would be most valuable in circumstances where current crop rotations are least profitable. In addition to traditional breeding criteria, development of a perennial grain crop should also consider forage qualities, dormancy and timing of regrowth as well as grazing tolerance. These dual-purpose traits may assist to offset lower grain yields and quality than annual grain crops. Alternatively, perennial wheat for crop-only production systems would require comparatively higher grain yields and/or grain qualities to attract premium grain prices or would need to be subsidised by payments for other services.

Acknowledgements
This work was funded by the Grains Research and Development Corporation and the CRC for Plant-based Management of Dryland Salinity.

References

Bell LW, Byrne F, Ewing MA, Wade LJ (2008) A preliminary whole-farm economic analysis of perennial wheat in an Australian dryland farming system. Agricultural Systems 96, 166-174.

Cox TS, Bender M, Picone C, van Tassel DL, Holland JB, Brummer EC, Zoeller BE, Paterson AH, Jackson W (2002) Breeding perennial grain crops. Critical Reviews in Plant Science 21, 59–91.

Davies CL, Waugh DL, Lefroy EC (2005) Variation in seed yield and its components in the Australian native grass *Microlaena stipoides* as a guide to its potential as a perennial grain crop. Australian Journal of Agricultural Research 56, 309–316.

Kingwell, R.S., Pannell, D.J. (Eds.) (1987) MIDAS, A Bioeconomic Model of a Dryland Farm System. Pudoc, Wageningen.

Ridley, A.M., Pannell, D.J., 2005. The role of plants and plant-based research and development in managing dryland salinity in Australia. Australian Journal of Experimental Agriculture 45, 1341–1355

Silburn MD, Robinson BJ, Freebairn DM (2007) Why restore marginal cropland to permanent pasture? – land resource and environmental issues. Tropical Grasslands 41, 139-153.

Ward PR (2006) Predicting the impact of perennial phases on average leakage from farming systems in south-western Australia. Australian Journal of Agricultural Research 57, 269–280.