Yield, soil water and economic benefits of fallow

Yvette Oliver CSIRO, **Rob Sands** Farmanco

KEY MESSAGES

- Long fallow increases soil water at sowing which in turn increases yield on good water holding capacity soils, particularly when the growing season rainfall is low (<210mm) and the summer rainfall was low (<100mm)
- On good water holding capacity soils, 22-29% of years following long fallow had an average yield increase of 0.46-0.59 t/ha at Dalwallinu, 39-47% of years had an average yield increase of 0.49-0.82 t/ha in Perenjori while at Merredin 37-60% of years had a 0.51-0.76 t/ha yield increase. On poorer soils less than 0.20 t/ha benefits occurred in 9% of years at both locations.
- Economic benefits over other rotations can be achieved with fallow on heavier soil types at Perenjori and Merredin using a set rotation of one fallow every five years.
- Fallow is likely to be more profitable than a legume rotation in Perenjori on loams and good sands unless you can achieve better than district average yields for the grain legumes grown.
- The opportunity cost in the year of fallow is critical, so don't fallow in a year that has an above average yield potential. The years with the best yield potential are years with good stored moisture at seeding and early sowing opportunities.

AIMS

A long fallow is when the paddock is taken out of production for a year, the weeds managed during this period and soil water accumulates since crop harvest. Management of long fallows is coming into focus in the context of two main drivers in the Wheatbelt WA. The first driver is the reduction in sheep numbers in the farming system, associated loss in pasture area and reduced options to control weeds in the out-of-crop phase of the sequence. The second driver is a perceived shift towards drier seasons, less reliable cropping and increasing reliance on crops to grow on stored soil moisture, as opposed to in-crop rainfall.

The size of the yield benefit, frequency of yield benefit, other benefits and cost of the fallow will determine whether fallow is an economic option in the WA wheatbelt region. In this paper we explain some of the determinants of attaining a yield increase from additional soil water at sowing and then carry this forward into an economic analysis of the inclusion of a fallow phase into the farming system.

METHODS

The crop simulation model, APSIM, was used to analyse the long term yield benefits to additional water from a long fallow (18 months fallow) after wheat (FW), compared to wheat after wheat (WW), (6 month summer fallow). Long term simulations for the period 1907-2010 were run for 3 locations; Dalwallinu represents the medium rainfall area of northern agriculture region (May-Sept 244 mm), Perenjori the low rainfall area northern agriculture region (May-Sept 224mm), and Merredin the low rainfall area in central Wheatbelt (May-Sept 194 mm). The soils chosen to represent the major soils of the area were: shallow sand (40mm), sand (90mm), loam (119mm) and clay-loam (189mm) with plant available water capacity (PAWC) in brackets.

For the APSIM analysis, high nitrogen rates were applied (90 kg N/ha at sowing and 90kg N/ha at 40 days after sowing) to gain the maximum benefits from the additional water from a fallow. The effect of previous seasons were removed on the two year rotation (FW, WW) with soil water, soil nitrogen and stubble reset on the 1st Nov in the year of the wheat after fallow (for FW) and the second wheat for WW. Wheat *cv.* Wyalkatchem was sown at 100 plants/m^2 between the 1 May and 30 June after 15 mm rainfall over 10 days, otherwise they were sown on the 30th June (average sow date was 21 May in Merredin and Perenjori and 18 May in Dalwallinu).

Under the assumption that a "break crop" is required, the economic analysis compared the rotational margins for a pasture-cereal rotation, a grain legume-cereal rotation and a fallow-cereal rotation, over a ten year period. The analysis uses the average yields, the fallow yield benefit and frequency of that benefit, which had been generated by the APSIM simulation runs. For example the average yield benefit of 0.8 t/ha occurs in 47% on years – then every second year would have a just 0.8 t/ha yield increase from a fallow. Costs and prices used in this analysis is shown in Table 1. Time of sowing and penalties for this were also used in the economic analysis and converted to an income loss for each rotation (Table 2).

Table 1. Opportunity cost and profit from different crops used in the economic analysis

	Income		**Costs $/ha**				**Profit**	
	Base Yield	Farm Gate	Fert	Herbicide	Other variable	Fixed	$/ha	$/t
Wheat	1.92	$250	$70	$50	$110	$95	$199	$81
Barley	2.02	$240	$70	$50	$110	$95	$159	$79
Grain Legume	0.60	$300	$25	$32	$110	$95	-$82	-$137
Fallow				$30		$95	-$125	-$125
	DSE	$/DSE			$/DSE			$/DSE
Pasture	2	$50			$27	$72	-$26	-$13

Table 2. Assumption on the penalty, sowing dates opportunities and income loss from Pasture, Grain Legume and Fallow

Timeliness of sowing	Penalty % / day	Days of seeding	Dry seed	Sown wet	Av. Timing discount	Income loss
Pasture	1.0%	20	7	13	0.0%	$0
Grain Legume	1.0%	30	6	24	5.3%	$22.48
Fallow	1.0%	24	6	18	2.3%	$11.24

With an extra cost in fertiliser and harvesting added to achieve the yield boost included in the economic analysis, with an additional 20 units of N and 3 of P and 1 harvest unit, to which was at an additional cost of $43. In this analysis we did account for additional N from Fallow, as we are comparing a fallow to pasture or legume which also may have supplied additional N to the soil (and not comparing to a continuous wheat rotation)

The analysis includes a time of sowing impact, and the difference in weed control costs for each rotation, to arrive at an estimated average rotational profit for each rotation, on each soil type.

RESULTS

Soil Water and Yield increase

Having a paddock under fallow for 18 months can increase the stored soil water in the profile (Table 3). However the difference in stored water between the continuous wheat (well managed summer fallow) and a long fallow can vary from year to year due to summer rainfall. High summer rainfall (>100mm) can fill the profile so the stored soil water is similar under long fallow and continuous wheat.

Table 3. The stored soil water (mm) at sowing under a continuous wheat and 18 month fallow at Dalwallinu and Perenjori for a clay-loam, loam, good sand and poor sand.

Soil type	Soil PAWC (mm)	Dalwallinu		Perenjori		Merredin	
		Continuous wheat	18 month fallow	Continuous wheat	18 month fallow	Continuous wheat	18 month fallow
Clay-Loam	189	50	113	46	111	36	102
Loam	119	43	88	42	86	37	81
Good sand	90	40	79	39	78	38	76
Shallow or poor sands	40	30	39	30	40	29	39

Whether this increase in stored soil water leads to an increase in yield depends on the growing season rainfall. When the growing season rainfall is greater than 210mm, it is unlikely that additional stored soil water (from long fallow or better summer fallow management) increase yield (Fig 1). By using 100 years of historical climate data, we can see how often the low growing season rainfall and higher stored water under long fallow (so low summer rainfall) combine to increase the yield from a long fallow, and the average yield increase (in the years an increase occurs) (Table 4).

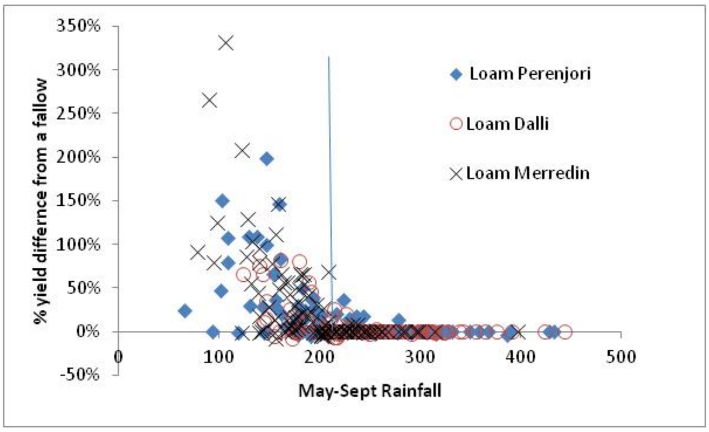

Fig 1. Percentage increase in yield from a fallow, with sufficient N, decreases as growing season (May-Sept) rainfall increases.

Table 4. Simulated average yield (100 years) for a continuous wheat (CW), the yield difference (for the years when a yield increase occurs) for a wheat after fallow (FW) and the % of years a yield increase occurs at Dalwallinu, Perenjori and Merredin for a clay-loam, loam, good sand and poor sand (70% of APSIM yield).

Soil type	**Dalwallinu**			**Perenjori**			**Merredin**		
	CW yield (t/ha)	Yield Inc for FW (t/ha)	% years of yield inc	CW yield (t/ha)	Yield Inc for FW (t/ha)	% years of yield inc	CW yield (t/ha)	Yield Inc for FW (t/ha)	% years of yield inc
Clay-loam	2.37	+0.59	29%	1.92	+0.82	47%	1.74	+0.76	60%
Loam	2.22	+0.44	25%	1.90	+0.49	41%	1.74	+0.51	50%
Good sand	2.14	+0.46	22%	1.79	+0.49	39%	1.70	+0.54	37%
Shallow or poor sands	1.39	+0.20	8%	1.20	+0.12	9%	1.12	+0.21	6%

The simulation study uses high nitrogen application so that there is sufficient N to meet the additional yield potential after a fallow.   If not enough N is applied (or accumulated through the fallow periods) the yield benefits will be less than the benefits shown in the simulation study.

However from other modelling work the increase stored mineral N from a fallow is 40-70 kg N/ha (Farre et al, 2012). When the yield benefit from a long fallow was determined under a standard N practice (14 kg N /ha sowing with 40 kg N/ha top-up) the combination of soil water and nutrient effect produced a higher long term average yield benefit (almost twice as much). This was because in low rainfall years the additional stored water from fallow increasing yield (as seen in the high N modelling scenario) but at high rainfall years the N contribution from fallow increased yield at this N application rate. This requires some more validation and results from trials on the N that is accumulated under both summer and winter managed fallows. The N accumulated over a fallow period will be dependent on the soil organic carbon, summer rainfall, previous cropping history and weed management over the fallow period.

Economics

The economic analysis looked at the rotations that are currently being used to achieve a sustainable rotation, with good weed control and compared it to a rotation which included a fallow once every five years (Table 4). The analysis shows that using a long fallow as part of a set rotation will only beat a pasture rotation on the heavy soils and in the lower rainfall areas such as Perenjori. The fallow rotation will be more profitable than grain legume rotations on the heavy and medium soils in the Perenjori area and will match the profitability of grain legumes in the Dalwallinu area.

The benefits from fallow will be improved when the profitability of the sheep enterprise is low, or on soil types where the grain legume yields are below average.

Rotations using a fallow phase should not be used on shallow and poor sands. An alternative land use to cropping should be considered, in view of the low levels of profit that are likely to be generated with a crop rotation.

The profitability of a rotation using a fallow phase could be improved through the strategic use of fallow in years when there is limited soil moisture at seeding and there is limited opportunity to sow early. This simple strategy will reduce the opportunity cost of the fallow considerably.

Table 5. Calculated average rotational profit from the simulated yields and yield boost calculated in table 4 with adjustments for time of sowing penalties and weed control costs.

	Average Rotation Profit $/ha								
Soil type	**Dalwallinu**			**Perenjori**			**Merredin**		
	Pasture /w/b 2.0 DSE/ha	Grain Legume /w/w/b/b	Fallow /w/w/b/b	Pasture /w/b 2.0 DSE/ha	Grain Legume /w/w/b/b	Fallow /w/w/b/b	Pasture /w/b 2.5 DSE/ha	Grain Legume /w/w/b/b	Fallow /w/w/b/b
Clay-Loam	119	114	114	103	95	108	76	60	76
Loam	106	100	97	99	91	97	76	60	68
Good sand	94	86	83	81	70	75	66	64	58
Shallow or poor sands	4	-29	-21	2	-24	-16	-27	-57	-63

CONCLUSIONS

A long fallow is a useful tool in a rotation to keep weed populations under control, and has less inherent risk than using a grain legume. A rotation using a fallow is likely to be more profitable than a rotation using a grain legume in the lower rainfall areas on medium to heavy soil types. Fallowing is likely to be more profitable than grain legumes on paddocks that have a poor yield history for grain legumes.

Fallowing is unlikely to be more profitable than a well managed sheep enterprise on a pasture rotation in the medium rainfall zone or the medium soil types in the low rainfall zone.

It is important that the opportunity cost of the fallow year be minimized through avoiding the high yielding years by developing rules of thumb on soil moisture at seeding and sowing times. More work in this area is needed before we can make any definitive recommendations.

Other Considerations

Pastures may be able to achieve many of the benefits of fallowing with a lower opportunity cost if shallow rooted species are utilised.

Grain legumes are not a good option for weed control where the ability to control radish and ryegrass is becoming more difficult as these weeds become resistant to more herbicide groups. Weed control in the fallow phase will put pressure on the highly valuable knockdown herbicide of glyphosate.

The APSIM model simulations for the last 100 years versus the last ten years shows that the last ten years has favoured fallowing more than the long term average, and fallowing will be less profitable if we enter a period of wetter years such as the 1990s.

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