SUMMER FALLOW MANAGEMENT EFFECTS ON SOIL MOISTURE FOR WINTER CROPS

SIMPLE PADDOCK SCALE COMPARISONS DURING THE SUMMER OF 2007/08

1. **Pasture cropping compared to a conventional spray fallow that was grazed**
2. **Effects of summer weed control strategy on soil moisture and soil nitrogen**

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Key points

- *The summer fallow period of 2007/08 was wetter than average and provided the opportunity to store summer fallow moisture for winter crops.*
- *Summer grasses and broadleaf weeds were found to use significant quantities of plant available soil moisture (56 and 77mm) and soil N (25kgN/ha) that could otherwise be used for winter crops.*

Background

Summer fallow management is well known to impact on soil moisture for following winter crops. Local benchmarking data (AgNvet Services) and surveys of local farmers and agronomists has identified improved fallow management as an area where considerable gains can be made by many farmers in Central West NSW to improve winter crop performance.

Despite this, the rising cost of fallow herbicides is causing farmers and their advisors to closely scrutinise the benefits of fallow maintenance. The advent of pasture cropping has furthered this debate to a small degree. Pasture cropping systems aim to produce cereal crops for grain or forage while retaining perennial grasses for grazing in fallow or ley period. The perennial grasses are not killed and are retained through the summer fallow and winter cropping phase. In Central West NSW summer active or C4 native perennial grasses usually dominant such pastures, although winter active native grasses may also be present. Winter crops are simply direct drilled into the retained perennial grasses. Some exponents of pasture cropping are claiming that improvements in ground cover, soil organic matter and soil biological health as a result of the continued presence of the perennial pasture more than compensate for the water use of the perennial pasture over summer, such that more summer moisture is captured and stored for the following winter crop rather than less moisture. Furthermore, pasture cropping removes the need for using summer fallow herbicides (although herbicide to suppress the pasture prior to sowing winter crops is generally required / recommended along with in-crop weed control). This new and challenging hypothesis seems to fly in the face of conventional fallow management thinking that focus's on the complete removal of growing plants. Much research has shown that summer growing plants, whether they be thought of as weeds or pasture are highly effective users of soil moisture and soil nutrients, two essential ingredients for winter crops that fallows aim to conserve and or build. This report details two simple comparisons made in the Forbes district of Central West

NSW over the summer of 2007/08 that helps to provide some objective data in the debate of fallow management ideas.

Methods

1. Comments specific to pasture cropping and conventional fallow comparison.

Soil moisture comparisons at the beginning of May 2008 were made between two paddocks in the Wirrinya district. These paddocks were both a grey clay. The paddocks were located side by side with the soil testing being conducted within 100m of each other by way of five soil cores to a depth of 1.3m.

The pasture crop paddock had not been conventionally cropped since 2000. Since then native perennial grass regeneration was allowed to occur, and more recently management has focused on encouraging native grass regeneration. In 2003 the paddock was fenced into cells to allow a cell grazing regime of high intensity grazing for short periods of time followed by a rest period to enable the pasture to recover. Oats was direct drilled into the paddock in 2005 and 2006 as part of a dual strategy aimed at stimulating the regeneration and growth of the native grasses, as well as providing increased winter feed and possible grain harvest. Volunteer oats formed a useful part of the winter feed production in 2007. Good summer rains during the summer of 2007/08 produced excellent native pasture growth. Monitoring also suggested that significant C4 native grass seedling recruitment also occurred during the summer of 2007/08. Ground cover was generally maintained at or above 30% during the summer period. The cooperating farmer reported very good grazing from the pasture cropping paddock. The paddock was sown to Tilga Barley in 2008.

The neighbouring fallow paddock was sown to wheat in 2007. This crop failed and was not harvested. Prior to this the paddock had been sown into wheat in 2006 and 2005. Grazing of the failed 2007 wheat crop began in late spring. Following good early summer rains the paddock was sprayed with a phenoxy herbicide in January 2008 to control the broadleaf weeds. The remaining grasses were kept grazed low, such that ground cover was often below 30%. The removal of only the broadleaf weeds was a conscious decision as the farmer decided the summer grasses would help to provide some grazing. However, the grass cover was sparse with ground cover often below 30%.

The presence of some grasses in the fallow paddock may have meant that the paddock was not a perfect fallow. However, it was a common strategy in the district and the location of the 2 paddocks side by side with similar soil types, offered the best available comparison between a pasture cropping system and a commonly used chemical fallow system used in the district. There was a marked difference in perennial grass content between the two paddocks, with the pasture crop paddock have substantially more grass content than the fallow paddock.

2. Comments specific to the comparison of summer weed control strategy on soil moisture and soil nitrogen.

A simple comparison was made within a paddock in the Waroo district in the summer of 2007/08 between a section of the paddock that had been sprayed over summer and a section that had not. The soil type was red brown loam. The soil testing comparison was made within 20m of the dividing line between the two fallow management zones of the paddock.

The paddock had a history of Oats and Ryegrass (baled) in 2007 and Barley in 2006. Wheat was planned for the paddock in 2008

On the 26th December 2007 approximately half the paddock was sprayed with a mix of glyphosate and phenoxy (Estercide 680 and Garlon) herbicides. This herbicide mix worked well in controlling a mix of grass and broadleaf weeds. Good summer rainfall meant grass and broadleaf weeds grew well on the unsprayed area exceeding 50% ground cover. The paddock was grazed for several weeks in March to reduce weed growth. In early April the whole paddock was cultivated in preparation for a winter crop.

3. Comments that apply to the soil testing at both sites

On the 2nd May, five soil cores were taken from each section of the paddock. The location and site details are provided below. The soil cores were broken into six sections being 0-10cm, 10-30cm, 30-60cm, 60-90cm, 90-120cm and 120-130cm. Soils sections were weighed wet and then dried in an over at 110^0C until the weights had stabilised.

The calculations listed below were used to work out the plant available water difference of each depth section. The bulk densities were assumed to be 1.25, 1.4, 1.4, 1.45, 1.45 and 1.5 kg/L for the depth sections from top down. These bulk density assumptions were drawn from the APSoil data base.

Gravimetric water content (%)
= Water content as a % of dry soil weight

Volumetric water content (%)
= Gravimetric water content **X** bulk density

PAW content difference (per 10cm depth)
= Volumetric water content (%) of fallow
– Volumetric water content (%) of pasture cropping

Total PAW difference(mm) = sum of the PAW differences at each depth section

Due to the fact that the comparisons reported here were between two paddocks with the potential for spatial bias of the soil core results, the result for each core at each depth is presented to help provide confidence in the repeatability of the data, rather just relying on the simple average alone.

Rainfall over the summer fallow period was taken from nearby farmer gauges. In most cases these gauges were several kilometres from the soil test site, and there may well have been some differences between what fell at the soil test site and what the local farmer recorded.

Soil samples from the sprayed and unsprayed fallow comparison we also collected and sent away to a commercial laboratory for soil testing of mineral N. Mineral N results in terms of kg N/ha were calculated by multiplying the soil test result (mg/kg or ppm) by the soil bulk density and layer thickness.

Results

Seasonal Conditions

Rainfall during the summer fallow period of 2007/08 was generally above the long term median (i.e. decile 5) for the Forbes district. Tables 1 and 2 show the rainfall at nearby farms houses to the soil test sites for the 2007/08 summer fallow period. At the Wirrinya site 274mm was recorded nearby the soil testing site, which calculated to be a decile 7.7 event when measured against the nearby long term Burcher rainfall gauge.

At the Waroo site 357mm was recorded nearby the soil testing site, which calculated to be a decile 8.8 event when measured against the nearby long term Waroo rainfall gauge.

Both sites received very good rainfall in the early parts of the fallow period (i.e. Nov and Dec), followed by median rainfall in Jan and then good falls again in February. Little rainfall occurred in April at both sites.

Table 1. The 2007/08 summer fallow rainfall at the Wirrinya site and the calculated decile rank when measured against the long term Gauge at Burcher (Post Office 050010).

	Nov	Dec	Jan	Feb	Mar	Apr	Fallow	Last summer with more fallow rainfall
Rainfall (mm)	94	69	30	50.5	12	19	274.5	1999/00
Decile rank	9.6	8.2	4.9	7.1	3.6	4.9	7.7	

* Decile figures were calculated from the long term Burcher (Post Office 050010) rainfall guage.

Table 2. The 2007/08 summer fallow rainfall at the Waroo site and the calculated decile rank when measured against the long term Gauge at Waroo (Geron 050020).

	Nov	Dec	Jan	Feb	Mar	Apr	Fallow	Last summer with more fallow rainfall
Rainfall (mm)	81	132	31	57	48	8.5	357.5	1992 / 93
Decile rank	9.0	9.6	5.6	7.5	7.5	2.8	8.8	

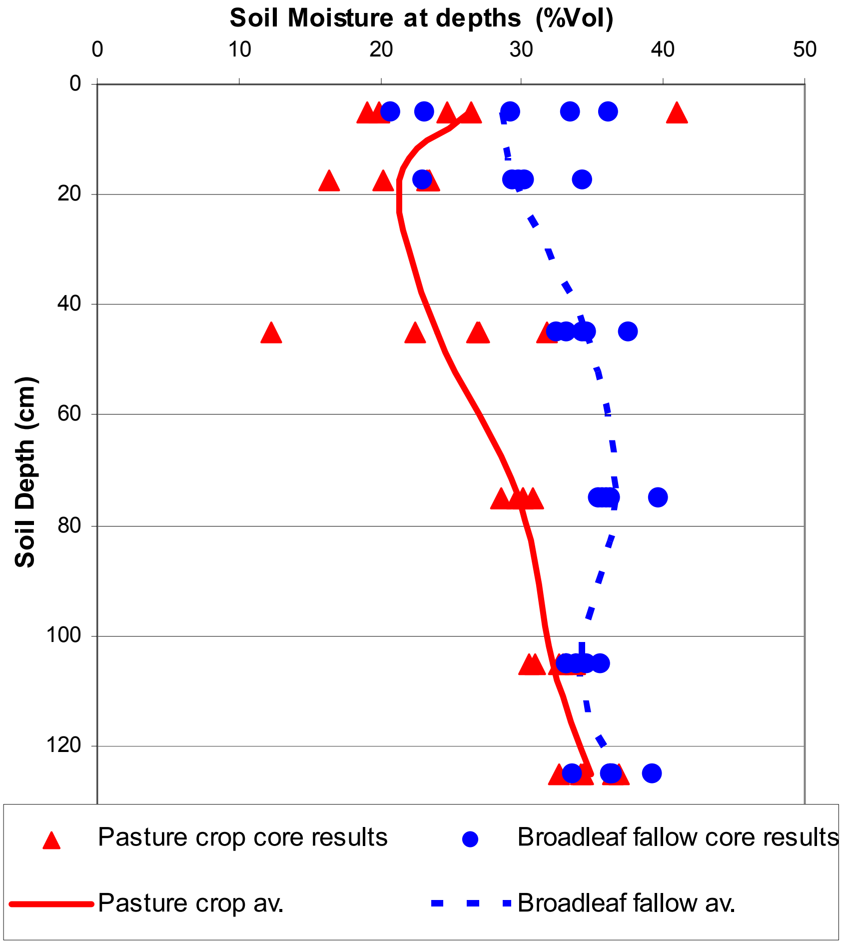
* Decile figures were calculated from the long term Waroo (Geron 050020) rainfall guage.

1. Pasture cropping compared to a conventional spray fallow that was grazed

The soil core test results presented in Graph 1 show the individual volumetric water results for each core at each depth. Table 3 shows the calculated Plant Available Water (PAW) difference at each soil depth. These results show that on the surface there was little difference in moisture content between the fallow and pasture cropping systems. On average in the surface soil there was only 2mm more PAW in the fallow system than the pasture cropping system (Table 3). However, the individual core results in Graph 1 show that the difference in the surface soil moisture was not consistent, with the pasture cropping system producing the wettest and the driest soil sample. This is supported by field observations at the time of testing, where it was thought that the large bulk of surface litter / mulch provided by the summer perennial grasses in the pasture cropping system appeared to be improving soil moisture retention from the recent April rainfall. However, the patchy and variable nature of the ground cover meant that the moisture levels were also highly variable in the top soil. The cooperating farmers commented that the pasture cropping paddock appeared drier at sowing in June compared to the fallow paddock.

At the depths of 10-30cm, 30-60cm and 60-90 cm the fallow system was obviously and consistently wetter than the pasture cropping system. The calculations in Table 2 indicate that on average the fallow system had 16mm, 31mm and 20mm more PAW than the pasture cropping system at 10 to 30cm, 30 to 60cm and 60 to 90cm depths respectively. Graph 1 shows that this effect was consistent, with each core from the fallow system being as wet, or wetter than the cores from the pasture cropping system. This difference in PAW was obvious when soil testing. The soil coring tubes were noticeably easy to push into the soil in the fallow system, while they were more difficult and slow to push into the pasture cropping system. There appeared to be little PAW difference between the pasture cropping and fallow systems at the depths of 90-120cm and 120-130cm.

The cumulative total PAW benefit for the whole soil profile of the fallow system over the pasture cropping system at the beginning of May was calculated to be 77mm. 67mm (87%) of this total benefit was in the depth zone of 10-90cm.



Graph 1. Comparative soil moisture chart between a paddock that was managed as part of a pasture cropping system and a paddock with a more conventional fallow management system (spray fallowing over summer with a broadleaf herbicide). Wirrinya site.

Table 3. The plant available water (PAW) benefit of a broadleaf weed fallow system over a pasture cropping system at the beginning of May 2008. Wirrinya site.

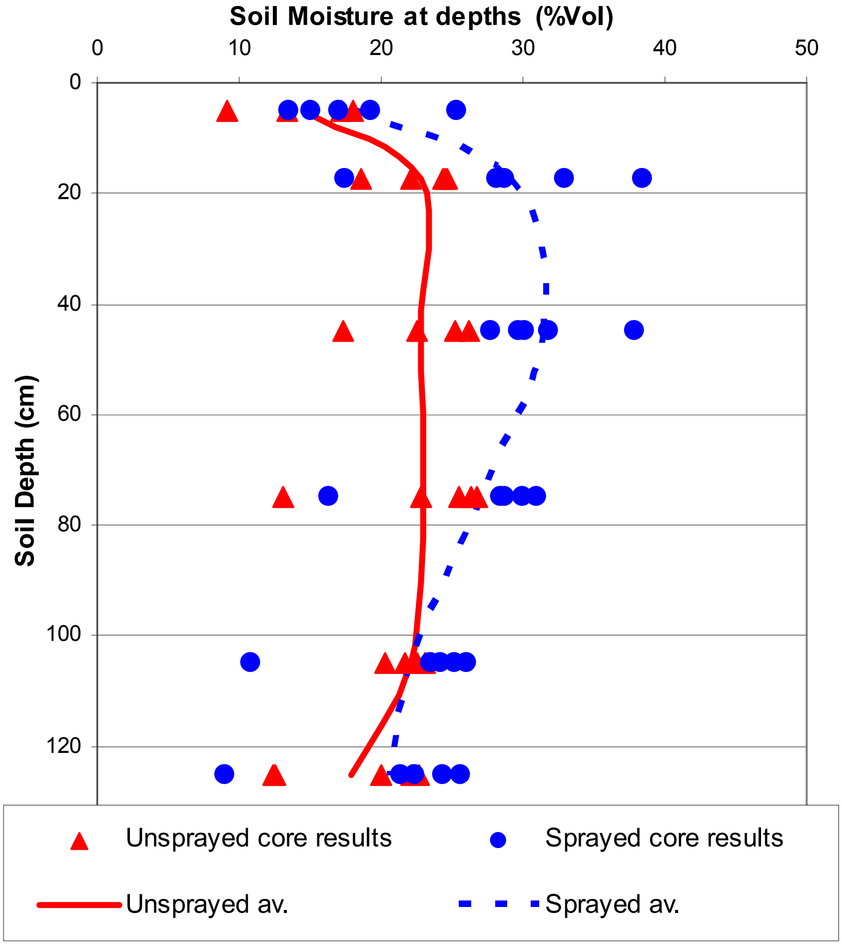
Soil Depth Range cm	Soil Depth Mid point cm	PAW benefit of Fallow over Pasture
0 - 10	5	2 mm
10 - 30	17.5	16 mm
30 - 60	45	31 mm
60 - 90	75	20 mm
90 - 120	105	6 mm
120 - 130	125	2 mm
Total PAW benefit		77 mm

2. Effects of summer weed control strategy on soil moisture and soil nitrogen

Graph 2 shows the individual volumetric soil moisture results from each core at each depth as well as the average soil moisture at each depth for the fallow management comparison at Waroo. These soil moisture results show little difference in the surface soil between the unsprayed and sprayed cores. At depth the cores from the sprayed area appeared to be wetter. One core at each depth of the sprayed cores appears to be an outlier in the data set, such that it is consistently drier than the other cores. This is obvious at all depth sections except for the 30-60cm section. The reason for this core laying being outside the data range of the other cores taken from within the sprayed area is not known. However, it does demonstrate the sort of variability that can occur with this type of soil testing.

The most consistent and pronounced difference in PAW was found at the depth range of 30-60cm, where all the cores from the sprayed area had more soil moisture than the unsprayed area and the average benefit of the sprayed over the unsprayed was 26mm for 30cm of soil depth.

Table 4 shows the average PAW benefit of the sprayed area over the unsprayed area for each depth section. The sum total PAW benefit of the sprayed over the unsprayed for whole 1.3m depth of soil tested was calculated to be 56mm.

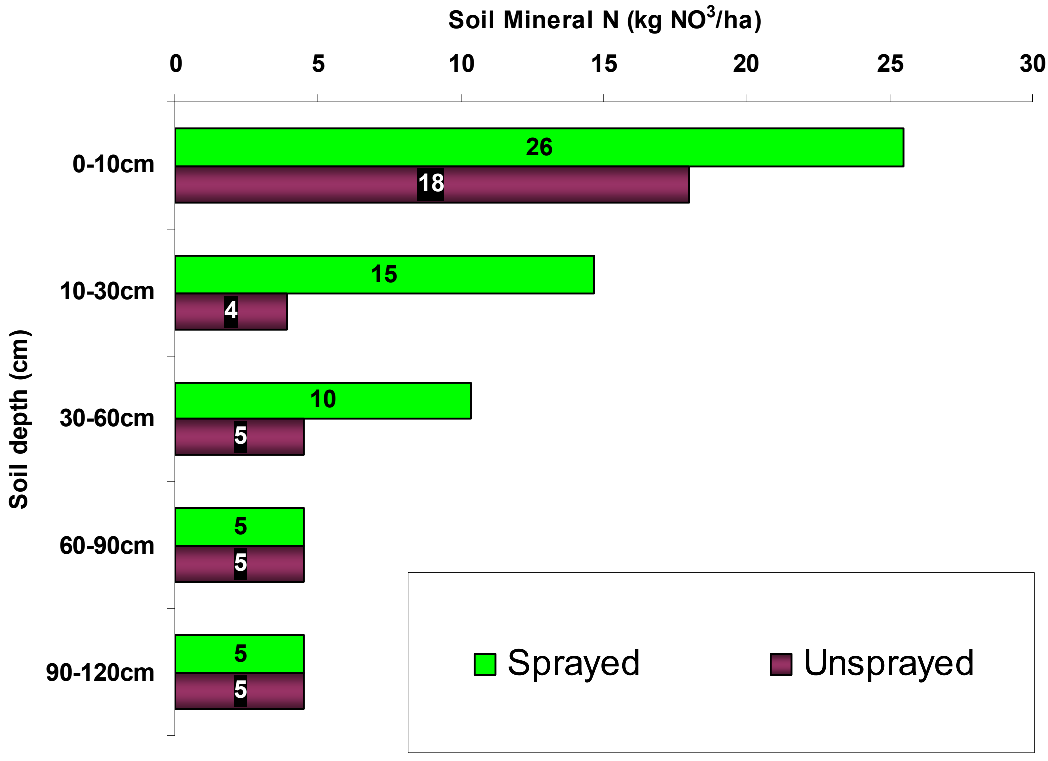


Graph 2. Comparative soil moisture chart between a section of a paddock that was sprayed with a grass / broadleaf herbicide application once during the summer fallow of 2007/08, and a nearby section of the same paddock that was not sprayed and summer weeds allowed to proliferate. Waroo site.

Table 4. The plant available water (PAW) benefit of one grass / broadleaf fallow herbicide application during the 2007/08 summer fallow. Soil test results taken at the beginning of May 2008. Waroo site.

Soil Depth Range cm	Soil Depth Mid point cm	PAW benefit of Sprayed over Unsprayed
0 - 10	5	4 mm
10 - 30	17.5	13 mm
30 - 60	45	26 mm
60 - 90	75	12 mm
90 - 120	105	-1 mm
120 - 130	125	3 mm
Total PAW benefit		56 mm

Graph 3 presents the soil mineral N results in terms of kg N/ha / layer thickness. Summing the results of these layers indicated that the sprayed soil cored had 60kg N/ha and the unsprayed cores had 35 kg N/ha. The soil N advantage of the fallow system was confined to the top 60cm of the soil. No differences in soil N levels were apparent deeper in the soil profile (i.e. 60-90cm and 90-120cm).



Graph 3. Comparative deep soil N results for a section of a paddock that was sprayed with a grass / broadleaf herbicide application once during the summer fallow of 2007/08, and a nearby section of the same paddock that was not sprayed and summer weeds allowed to proliferate. Cumulative total mineral N for the sprayed soil cores = 60kg NO^3/ha. Cumulative total mineral N for the unsprayed cores = 35kg NO^3/ha. Waroo Site.

Crop monitoring on the 31st October 2008 suggested a marked visual difference in crop performance between the sprayed and unsprayed areas. This difference was confirmed by tiller counts which indicated an average of 440 tillers/m^2 in the sprayed area and 270 tillers/m^2 in the unsprayed area. Little difference was found in the number of grains/head, with both sides having approximately 20 grains/head. Based on these measurements, it was estimated that the sprayed area had a yield potential of 2.6t/ha and the unsprayed area had a yield potential of 1.6t/ha. Simple calculations show that an extra 1t/ha of grain from the extra 56mm of soil moisture equates to a water use efficiency (WUE) of approximately 18 kg grain/mm from the stored soil moisture. Such a result is in-line with recent research results that have shown WUE's from sub soil moisture in the order of 20kg/mm.

Conclusion

The results from these two fallow management comparisons show that fallow management can have a significant impact on the amount of stored soil moisture for winter crops. Pasture cropping at Wirrinya was found to result in 77mm less stored PAW than a conventional broadleaf fallow by the beginning of May. One application of fallow herbicide in late December and the resultant weed control at Waroo was found to result in 56mm more PAW by the beginning of May. This effect was most consistent and pronounced in the depth range of 30-60cm at both sites. In addition to the water conservation benefits at Waroo, the one fallow herbicide resulted in an additional 25 kg N/ha in the top 60cm of soil.

Based on the results of these two comparisons, C4 summer grasses appear highly efficient users of soil water and nitrogen. Recent research has highlighted that sub soil moisture can potentially produce good cereal grain water use efficiencies in the order of 20kg/mm. A simple calculation using this assumption suggests that 50mm of sub soil moisture could be worth approximately 1t/ha of grain and 75mm could be worth approximately 1.5t/ha. Fallow moisture and soil N are inherently linked through the biological process of mineralisation. Soil moisture is one of the key drivers of N mineralisation, an important process in conventional fallows. In addition to this effect, summer grasses are known to forage for soil N. Research at Wellington has highlighted that N deficiency commonly limits winter cereal grain yields in pasture cropping systems.

The presence of summer grasses at both sites meant that much of the opportunity for storing soil moisture in the summer of 2007/08 was lost. The soil water loss was compounded by the additional loss in soil N. The hypothesis that improvements in ground cover and soil biology from perennial C4 grasses outweighs their potential for water use, is not supported by these two comparisons. Rather these comparisons suggest very much the opposite, in that summer active C4 perennial grasses appear to be a highly effective way of using summer soil moisture and N.

This is not to discredit the potential of pasture cropping systems to benefit mixed farmers that have a significant livestock focus as part of their business and management that focuses on profiting from the additional summer dry matter a pasture cropping system produces. For these mixed farmers the additional livestock production obtained from the summer grasses and lack of herbicide expenditure over the summer period may go some way towards making up for the additional water use of the summer pasture (and thus reduced winter cereal grain yield potential). Pasture cropping is seen as a lower input / lower output system, where the addition of livestock adds diversity and reduces down side risk.

The other important factor to consider is the impact of seasonal conditions. The summer of 2007/08 was wetter than average. The combination of good rainfall and follow up rainfall events during the fallow period helped to push the soil moisture deeper down the soil profile than might other wise have occurred in a drier summer, thereby reducing the potential for evaporative losses. Summer fallow conditions of low and sporadic rainfall could very well reduce the ability to store moisture in the sub soil in traditional fallows and thus reduce the benefits of grass removal. It is hoped to continue these fallow management comparisons over the next few seasons to provide a more complete picture of seasonal effects.

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