Final Technical Results Report

2024

Fallow Management and the Economic Costs

Project code:	LAK2204-002SAX
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REPORT SENSITIVITY

Does the report have any of the following sensitivities?

Intended for journal publication	YES ☐ NO ☒
Results are incomplete	YES ☐ NO ☒
Commercial/IP concerns	YES ☐ NO ☒
Embargo date	YES ☐ NO ☒ If Yes, Date: <Choose date>

Contents

ABSTRACT

GRDC established this project to determine the agronomic and financial benefits of different fallow management practices in Western Australia's low rainfall zone. Six farm scale trials were established across the Kwinana East port zone. Each trial had four treatments: 1) cereal, 2) vetch, 3) volunteer pasture, and 4) brown out. In 2023, each trial site was sown 'as per grower practice'. Trials were monitored for soil water, soil N, groundcover, grain yield and quality. An economic analysis for each treatment was also completed.

The cereal treatment recorded the highest gross margin. However, feedback from growers during the project suggested that when the non-cash benefits of fallow are considered, it has a positive economic benefit to the farm business.

Growers considering fallow should implement a 'brown out' practice, keep paddocks weed free and maintain groundcover. This practice results in the highest amount of stored soil water, allows N to accumulate and be available for the following crop and provides an opportunity to control glyphosate resistant ryegrass.

EXECUTIVE SUMMARY

Growers in the GRDC National Grower Network across the Kwinana East port zone raised an issue: a lack of knowledge on fallow was impeding the adoption of the rotation. In response, GRDC established a project to determine the agronomic and financial benefits of different fallow management practices in the low rainfall zone of Western Australia.

In 2022, six farm scale trials were established, managed, and harvested using grower machinery. Trials were established near Kalannie, Gabbin, Bonnie Rock, Nungarin, Hines Hill, and Merredin. Each trial had four treatments: 1) cereal, 2) vetch, 3) volunteer pasture, and 4) brown out. In 2023, each trial site was sown 'as per grower practice'. Trials were monitored for soil water, soil N, ground cover, grain yield and quality. An economic analysis for each treatment was also completed.

Key messages

1. Growers considering fallow should implement a 'brown out' practice, keep paddocks weed free and maintain ground cover. This practice results in the highest amount of stored soil moisture, allows N to accumulate and be available for the following crop and provides an opportunity to control glyphosate resistant ryegrass.

2. Saving 1mm of plant available water costs $4/ha.

3. The cereal on cereal treatment recorded the highest gross margin. Despite the gross margin of the brown out practice being lower than cereal on cereal, feedback gathered from growers during the project suggests it does have a positive economic benefit to the farm system overall. Perhaps fallow is best considered a strategic investment and recorded as an asset on the grower's balance sheet.

Based on feedback from growers across the low rainfall zone, GRDC has created a new project that will monitor these trial sites in 2024 and 2025. More information about these trial sites can be found by searching for the project code LAK2402-001SAX.

BACKGROUND

Growers in the low rainfall zone (LRZ) of Western Australia (WA) are interested in fallow. However, some growers are hesitant to adopt the practice because there are knowledge gaps in what is the best fallow system to adopt, what the impact of different fallow systems is on soil moisture, soil nitrogen, grain yield and quality, and what the economic effects of different fallow systems are. This project was initiated in response to issues raised by growers in the GRDC National Grower Network (NGN) in the Kwinana East port zone.

Past research (Developing farming systems for the LRZ of WA - CSA00056) reported a 0.62 t/ha grain yield increase in wheat after fallow compared to the continuous wheat rotation at Merredin. At Hyden, there was a 0.45 t/ha increase in wheat yield in the fallow-wheat-fallow-wheat rotation compared to the continuous wheat rotation.

This report details the results of six farm-scale trials established and monitored in the eastern WA wheatbelt between 2022 and 2023.

PROJECT OBJECTIVES

To determine the agronomic and economic benefits of different management practices in a fallow farming system in the Kwinana East port zone.

METHODOLOGY

In May 2022, six trials were established near Merredin, Nungarin, Hines Hill, Bonnie Rock, Kalannie, and Gabbin. All trials were farm-scale. The plots were 200 m long x the width of the grower's boom spray, which varied between 36 m and 55 m. Each trial had four treatments: 1. cereal (barley at Nungarin, all remaining sites wheat), 2. vetch, 3. volunteer pasture, and 4. brown out.

The cereal treatment was managed as per grower practice. Vetch was sown at 40 kg/ha and 10 kg/ha of Alosca®. The volunteer pasture treatment consisted of a mix of plant species (radish, ryegrass, and self-sown crop from the previous rotation) growing in each plot. The brown out treatment was kept bare for the growing season using chemicals. The vetch, volunteer pasture, and brown out treatments were sprayed in early September 2022 before seed set. All trials were kept weed free over 2022/23 summer.

In 2023, all sites were sown to wheat except for Kalannie, which was sown to canola.

Over both years of the project, the grower hosting the trial used their machinery to seed, fertilise, spray, and harvest the trial.

In April 2022, soil samples were collected at each trial site at 0-10 cm, 10-30 cm, and 30-60 cm and sent for a comprehensive soil test (Table 1).

In October 2022 and April 2023, soil samples were taken from each plot at depths of 0-10 cm, 10-20 cm, 20-30 cm, 30-40 cm, 40-50 cm, and 50-60 cm and sent for soil moisture analysis.

Soil samples were collected in April 2023 and April 2024 at 0-10 cm, 10-20 cm and 20-30 cm and analysed for nitrate and ammonia to determine the amount of soil nitrogen in each treatment.

Before harvest in 2023, a 1.5 kg grain sample was collected from each plot at all trials and analysed for protein.

After harvest in 2022 and 2023, the yield map was collected from the grower, the trial layout was overlaid, and the yield data was extracted from each plot.

Data was statistically analysed using ANOVA at $p>0.10$.

In 2022, all trials received well above-average rainfall, ranging from 407 mm at Hines Hill to 345 mm at Kalannie. Rainfall in 2023 was the opposite; all sites received well below-average rainfall, ranging from 167 mm at Kalannie to 206 mm at Hines Hill (Table 2).

Table 2: Rainfall for 2022 (mm), 2023 and average for each trial location.

Trial location	2022	2023	Average rainfall
Merredin	394	197	296
Nungarin	351	189	280
Hines Hill	407	206	312
Bonnie Rock	396	175	291
Kalannie	345	167	296
Gabbin	348	224	302

Economic analysis was completed using a combination of quantitative and qualitative methods. Over the project's life, management practices and costs for each treatment were collated. Combined with grain yield and price, this information was used to complete a gross margin analysis. In addition, a survey of growers hosting the trials was completed to assess fallow's whole farm economic impact.

Table 1: Soil properties at three depths for each location before establishing the trials.

	Merredin	Nungarin	Hines Hill	Bonnie Rock	Kalannie	Gabbin
Soil type	loam	clay/loam	loam	sandy loam	sandy loam	sandy loam
0-10 cm						
Nitrate (mg/kg)	7.80	5.68	4.7	9.4	1.1	9.2
Ammonium N (mg/kg)	<1	1.3	<1	1.8	1.7	<1
Colwell Phosphorus (mg/kg)	19	32	17	23	5	23
Colwell Potassium (mg/kg)	360	130	560	70	110	54
pH $CaCl^2$ (pH units)	7.87	5.68	7.83	4.44	4.78	5.78
10-30 cm						
Nitrate (mg/kg)	5.9	7.13	1.9	4.1	<1	5.4
Ammonium N (mg/kg)	<1	<1	<1	<1	<1	<1
Colwell Phosphorus (mg/kg)	<5	5	<5	<5	<5	<5
Colwell Potassium (mg/kg)	130	46	230	58	60	38
pH $CaCl^2$ (pH units)	8.15	7.13	8.14	5.11	4.71	4.72
30-60 cm						
Nitrate (mg/kg)	1.1	7.46	<1	4.7	<1	2.9
Ammonium N (mg/kg)	<1	<1	<1	<1	<1	<1
Colwell Phosphorus (mg/kg)	<5	<5	<5	<5	<5	<5
Colwell Potassium (mg/kg)	120	46	250	140	66	100
pH $CaCl^2$ (pH units)	8.36	7.13	8.14	6.43	5.74	6.41

LOCATION

Site #	Latitude (decimal degrees)	Longitude (decimal degrees)	Nearest town
Trial Site #1	-30.917679	118.220764	Merredin
Trial Site #2	-31.1858104	118.1127286	Nungarin
Trial Site #3	-31.549896	118.097393	Hines Hill
Trial Site #4	-30.514566	118.237717	Bonnie Rock
Trial Site #5	-30.351444	116.857336	Kalannie
Trial Site #6	-30.855695	117.659606	Gabbin

If the research results are applicable to a specific GRDC region/s (e.g. North/South/West) or GRDC agro-ecological zone/s, indicate which in the table below:

Research	Benefiting GRDC region (select up to three)	Benefitting GRDC agro-ecological zone	
Fallow management and the economic costs	Western Region Choose an item. Choose an item.	☐ Qld Central ☐ NSW NE/Qld SE ☐ NSW Vic Slopes ☐ Tas Grain ☐ SA Midnorth-Lower Yorke Eyre ☒ WA Northern ☒ WA Eastern ☐ WA Mallee	☐ NSW Central ☐ NSW NW/Qld SW ☐ Vic High Rainfall ☐ SA Vic Mallee ☐ SA Vic Bordertown-Wimmera ☐ WA Central ☐ WA Sandplain

RESULTS

Soil Moisture

In October 2022, all trials were sampled to 60 cm to determine the effect of different treatments on soil water. The brown out treatment recorded the highest amount of stored soil water, followed by the volunteer pasture and vetch treatments. These treatments had 38%, 21%, and 5%, respectively, more soil water than the cereal treatment (Table 3). The distribution of soil water down the profile for each trial can be seen in Figure 1.

Table 3: Total water (mm) in the soil profile to 60 cm in October 2022.

Trial location – soil type	Barley	Wheat	Pasture	Vetch	Brown Out	Average
Merredin - loam		73	104	86	99	91
Nungarin – clay/loam	88		107	84	114	102
Hines Hill - loam		73	78	80	86	79
Bonnie Rock – sandy loam		45	50	47	78	55
Kalannie – sandy loam		44	67	50	82	61
Gabbin – sandy loam		52	50	49	60	53
Relative to Cereal			21%	5%	38%	

The Nungarin trial site recorded the highest soil water level, 102 mm (Table 3), in October 2022. However, on closer analysis of the results, the soil contained very high levels of boron. The desired level for boron ranges between 0.5 and 2.0 mg/kg, at this site, it was as high as 17 mg/kg. Figure 2 shows the interaction of soil water at depth with boron in the soil.

In April 2023, just prior to the growing season, soil water at each site was measured again. The aim was to determine if the soil water differences recorded between treatments in October 2022 (Table 3) carried over the summer and be available to benefit the 2023 crop. However, due to rainfall received during summer, which ranged from 23 mm at Kalannie to 123 mm at Gabbin, no differences were recorded between treatments (Table 4).

Table 4: Total water (mm) in the soil profile to 60 cm in April 2023.

Trial location – soil type	Barley	Wheat	Pasture	Vetch	Brown Out	Average
Merredin - loam		101	104	69	88	91
Nungarin – clay/loam	103		102	116	110	109
Hines Hill - loam		76	86	89	81	83
Bonnie Rock – sandy loam		55	63	63	47	57
Kalannie – sandy loam		45	45	43	66	50
Gabbin – sandy loam		51	56	50	53	53
Relative to Cereal			6%	0%	-2%	

Figure 1: Soil water at the Nungarin trial site in September 2022.

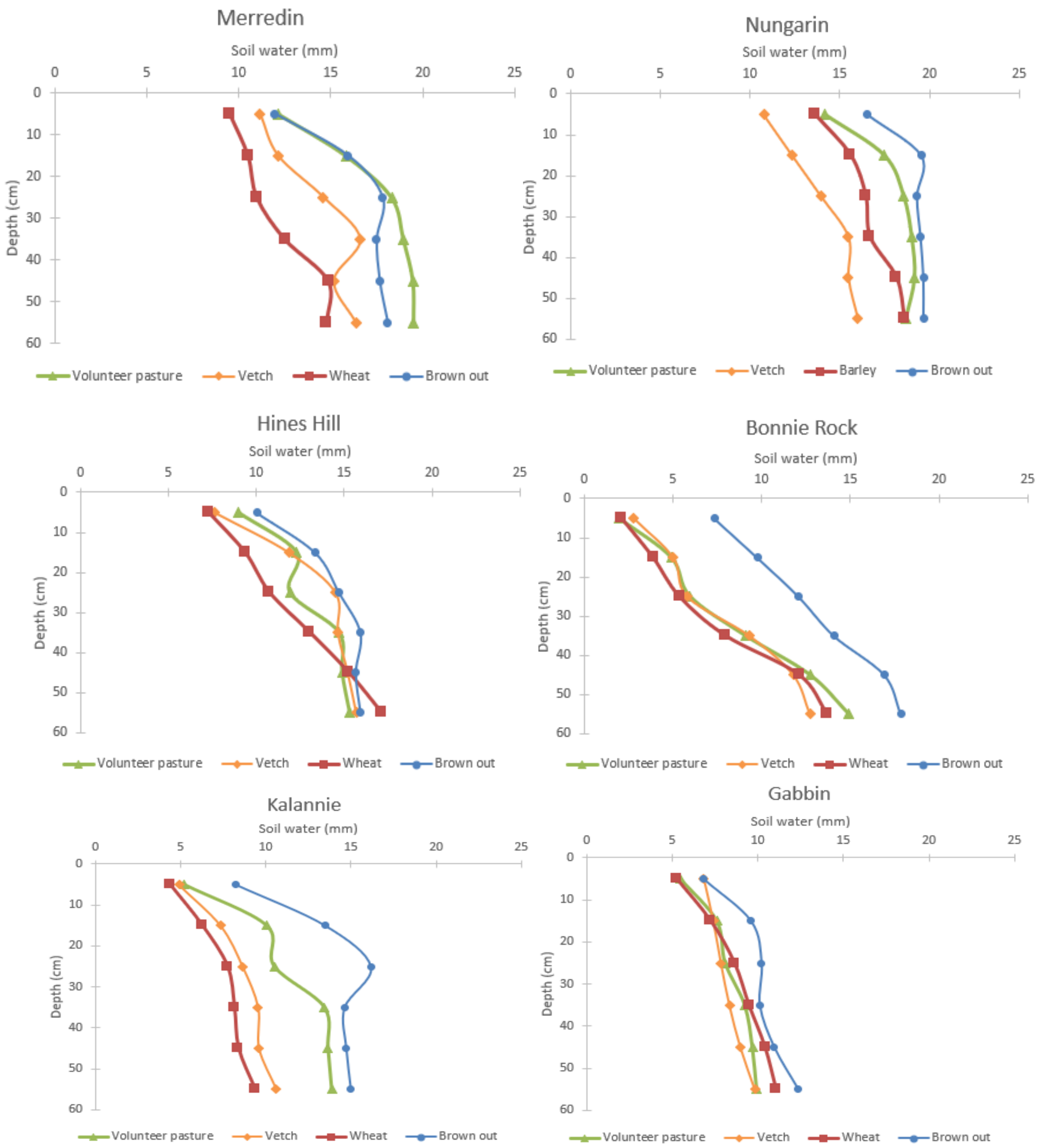

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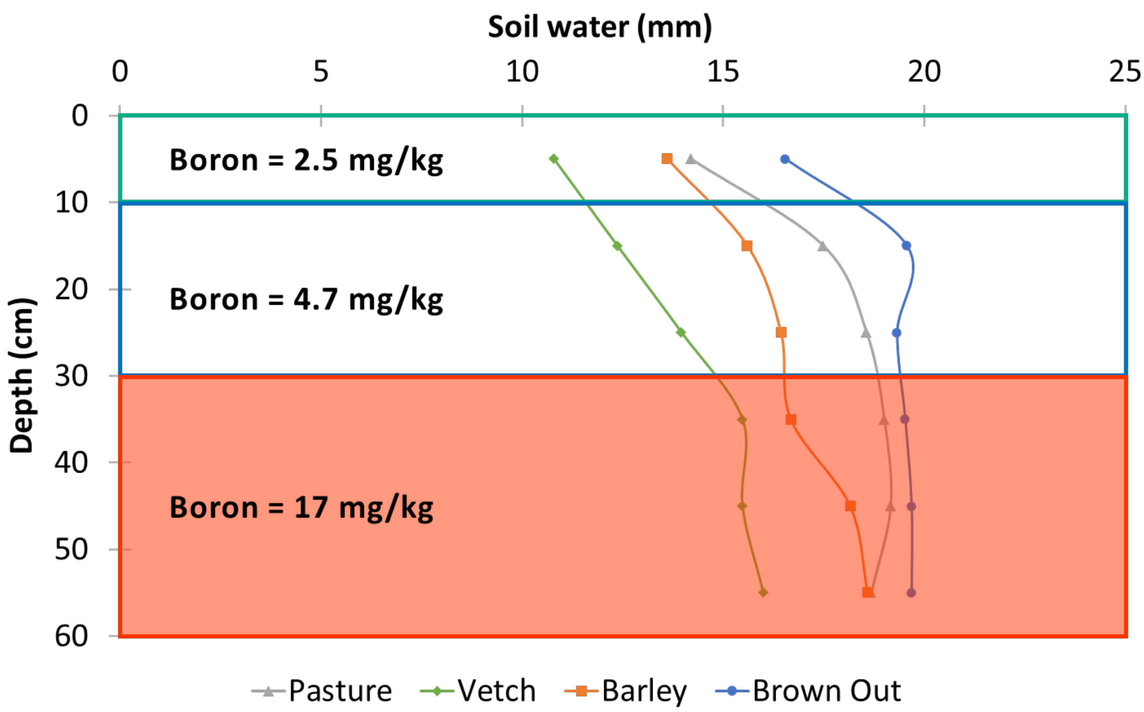
Figure 2: Soil water at the Nungarin trial site in September 2022

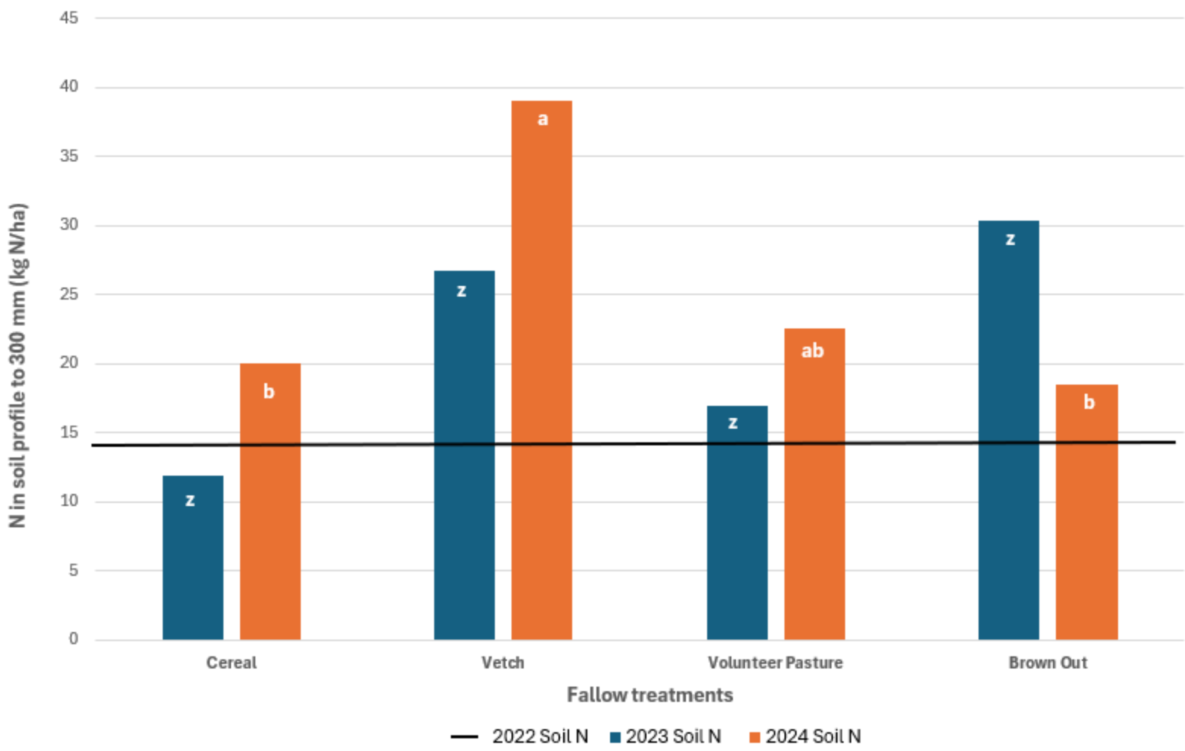


Soil Nitrogen

Before the trials were established, the soil contained 14 kg N/ha, on average, across all sites. Soil samples collected in April 2023 indicated higher soil N under the vetch and brown out treatments, 23 and 30 Kg N/ha, respectively. By comparison, the cereal treatment had 12 kg N/ha. By April 2024, differences in soil N between treatments ranged from 18 kg N/ha for brown out to 39 kg N/ha for vetch (Figure 3).

Vetch is a legume, which explains the increase in soil N compared to other treatments. The increase in soil N from the brown out treatment recorded in April 2023 is likely due to mineralisation over the 2022 growing season and 2023 summer. It is interesting to note the increase in soil N between April 2023 and April 2024 for the vetch treatment and a reduction in soil N for the brown out treatment over the same period.

Figure 3: Differences in soil nitrogen (kg N/ha) measured in April 2023 and April 2024 for treatments across the six fallow trials.



Statistical analysis was carried out between treatments within an assessment timing and not across assessment timings. Treatments followed by the same letter are not statistically significant.

Ground cover Assessment

In July 2022, no significant differences were observed between treatments. By September, this had changed. Vetch (59%) recorded the most ground cover, followed by cereal (40%) and volunteer pasture (35%). This trend continued in the January 2023 assessment. By April 2023, cereal had the highest ground cover (35%). Over the four assessment timings, brown out recorded the lowest level of ground cover (Figure 4).

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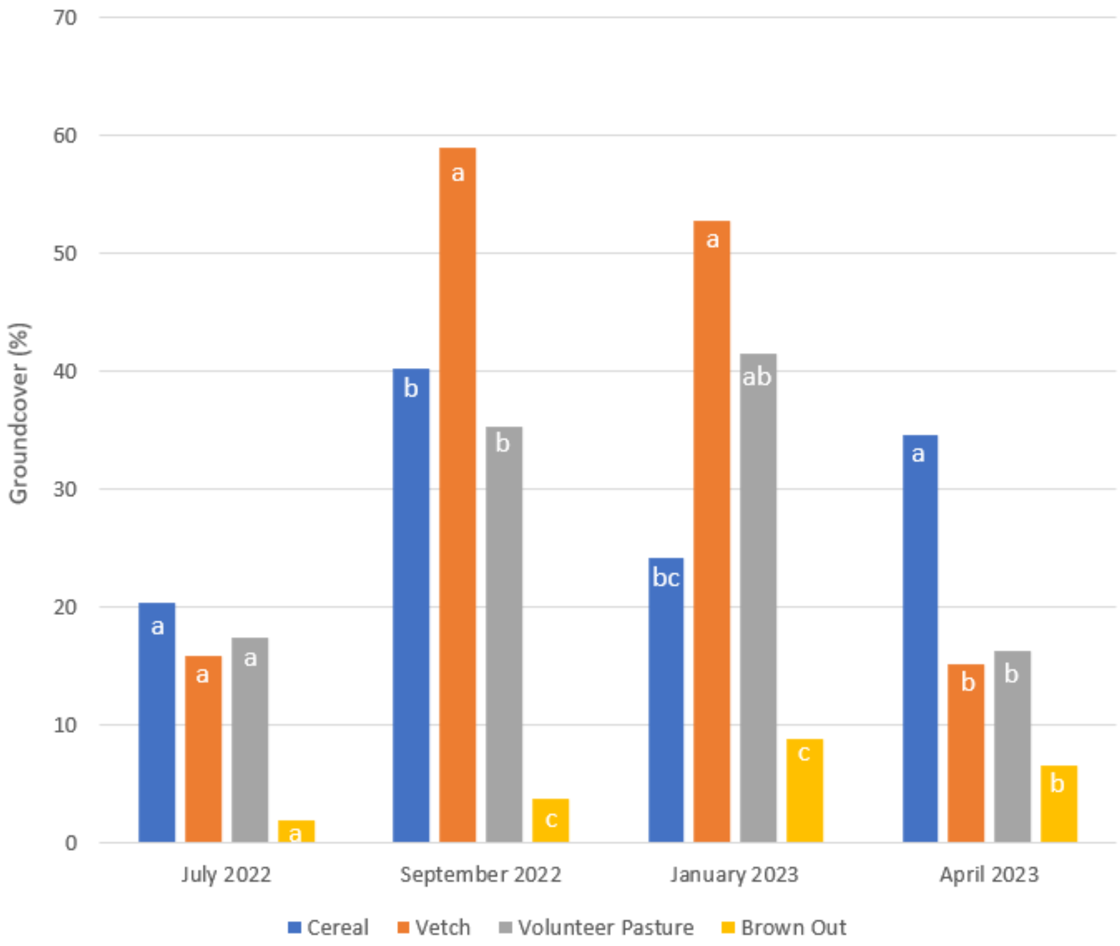
Figure 4: Ground cover (0% = no ground cover, 100% = complete ground cover) at four assessment timings.



Statistical analysis was carried out between treatments within an assessment timing and not across assessment timings. Treatments followed by the same letter are not statistically significant.

Grain Yield and Quality

The brown out and volunteer pasture treatments resulted in a grain yield increase of 0.47 t/ha and 0.43 t/ha, respectively, compared to the cereal treatment. This result is consistent with grower observations gathered during the project, which indicated that yield increases in cereals following fallow are about 0.5 t/ha. The yield increase in cereal following vetch was 0.33 t/ha (Table 5).

All fallow practices increased grain protein, ranging from 1.18% in cereals grown after vetch to 0.45% in cereals grown after volunteer pasture (Table 6).

Table 5: Grain yield (t/ha) for the cereal treatment in 2022 and all treatments in 2023.

Trial Location	Cereal 2022	Cereal 2022[e] Crop 2023[f]	Vetch 2022 Crop 2023[f]	Volunteer Pasture 2022 Crop 2023[f]	Brown Out 2022 Crop 2023[f]	LSD
Kalannie	2.49	0.17[d]	0.47[b]	0.32[c]	0.70[a]	0.15
Bonnie Rock	2.94	1.05[b]	1.45[a]	1.51[a]	1.41[a]	0.18
Nungarin	0.66	1.19[b]	1.45[a]	1.38[ab]	1.57[a]	0.20
Hines Hill	2.61	1.50[b]	1.99[a]	2.11[a]	2.20[a]	0.31
Merredin	1.72	1.02[c]	1.19[bc]	1.48[a]	1.44[a]	0.25

[e]Trial at Nungarin was sown to barley in 2023. [f]The trial at Kalannie was sown to canola in 2023, all other trials were sown to wheat. All other sites were planted with wheat. Grain yield results from the Gabbin site were not available in time to be included in this report. Grain yield followed by the same letter is not statistically significant p=<0.1.

Table 6: Grain protein (%) in wheat sown in 2023 following the 2022 treatments.

Trial Location	Cereal	Vetch	Volunteer Pasture	Brown Out	LSD
Gabbin	10.10[c]	11.10[ab]	10.90[bc]	11.80[a]	0.80
Bonnie Rock	11.20[c]	13.70[a]	11.90[bc]	12.20[b]	0.95
Nungarin	9.67[c]	13.20[a]	10.97[b]	12.03[b]	1.10
Hines Hill	10.30[b]	9.60[c]	11.20[a]	10.10[bc]	0.50
Merredin	11.00[c]	12.9[a]	10.40[c]	11.40[b]	0.70

Oil content for the canola at Kalannie was lost due to a sampling error. Grain protein followed by the same letter is not statistically significant p=<0.1.

Economics

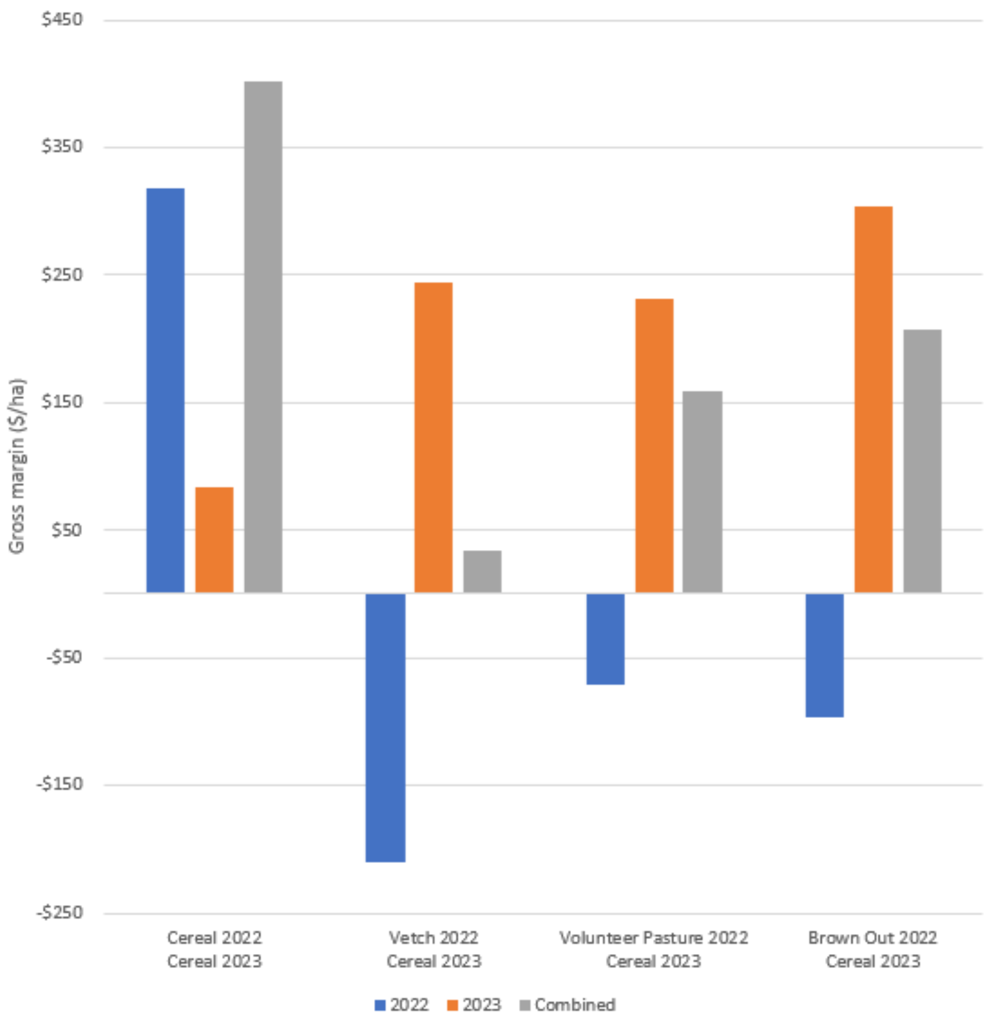
In 2022, the cereal treatment returned a gross margin (GM) of $318/ha. All other treatments had a negative gross margin ranging from -$71/ha for volunteer pasture to -$211/ha for vetch. The reason vetch recorded a big loss was due to the high cost of seed, $60/ha (seed purchased at $1,500/t and sown at 40 kg/ha). If growers consider using vetch as a fallow crop, reducing the cost of seed will increase financial returns. An extra spray in July 2022 on the brown out treatment is why this treatment is $26/ha more than the volunteer pasture treatment.

In 2023, cereal grown after brown out returned the highest financial return, $304/ha, and cereal on cereal was the lowest at $84/ha.

Over the two years of the project, the cereal on cereal treatment was the most profitable ($402/ha). This was followed by cereal after brown out ($207/ha), cereal after volunteer pasture ($160/ha) and cereal after vetch ($33/ha) (Figure 6).

In addition to the GM financial analysis a survey of growers hosting the trial sites was completed to assess the whole farm economic benefits of fallow. Results from this indicated that they were generally all aware of the lower cash returns from fallow compared to a cereal on cereal rotation. However, they did report other benefits from fallow, such as improved weed control, fewer issues with herbicide carryover, 'it makes farming easier', reduced risk, increased machinery utilisation, and improved confidence. One grower said, "You can only grow wheat on wheat for so long until the system falls over". The growers indicated that these 'intangible benefits' of fallow, which can be difficult to measure in cash returns, combined, lead to fallow having an overall positive financial benefit on the farm system and why they are adopting the practice.

Figure 5: The fallow project's gross margin ($/ha) analysis.



DISCUSSION OF RESULTS

The cereal treatment returned the highest gross margin over the two years of this project, $195/ha more than the next best treatment, brown out. While important, saving water and increasing soil N does not provide the short-term cash requirements for farming businesses in the LRZ, especially in an environment of rising input costs. This is why some growers aren't adopting fallow. However, grain growing in the low rainfall zone is a complex farming system; over the longer term, a continuous cereal rotation will create problems that need to be corrected. Fallow is a rotation option growers can adopt to keep the system in balance.

The results from this project indicate that growers looking to implement fallow should adopt the brown out practice. They should maintain maximum stubble cover to prevent water losses through evaporation and act as a barrier to minimise water runoff from intense rainfall during summer thunderstorms.

The brown out treatment had 24 mm more soil water than the cereal treatment. The value of this water, assuming 15 kg/ha water use efficiency (Planfarm Benchmarks 2022) and a wheat price of $300/t, is an extra 360 kg/ha or $108/ha.

While not statistically significant, the brown out treatment had 18 kg N/ha more than the cereal treatment prior to the 2023 growing season.

It is interesting to note the differences in soil N for the brown out treatment in April 2023 and April 2024. The likely reason for this result is that while the plots were kept weed free during the 2022 growing season, N mineralised from organic carbon in the soil, which led to an increase in soil N recorded in April 2023 compared to the cereal treatment. In 2023, this N was used by the crop and contributed to the extra yield of the brown treatment over the cereal treatment. By April 2024, the level of soil N between the brown out and cereal treatments was similar.

In 2023, the combination of extra water and N in the brown out treatment resulted in a 0.47 t/ha higher grain yield and $220/ha higher gross margin compared to cereal the cereal treatment. These results need to be put in context, and it should be noted that over the two years of the project, the brownout treatment recorded a gross margin $195/ha lower than the cereal treatment. Further discussion on economics in the context of the whole farm are provided below.

Although $26/ha cheaper than brown out, the volunteer pasture treatment is not recommended for growers to adopt, this practice stores less soil water and has less soil N than brown out; weeds use the water and N, meaning less is available for the following crop. Over the two years of the project, the volunteer pasture treatment recorded a gross margin $242/ha lower than the cereal treatment. An observation made during this project was the high presence of glyphosate resistant ryegrass across the LRZ. Growers adopting a volunteer pasture practice are missing an opportunity to control these resistant weeds during the growing season.

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Vetch has a place in the low rainfall farming system; however, it is an opportunistic fallow practice and will require increased management skills from the grower.

In this project, vetch used a similar amount of water during the growing season compared to the cereal treatment. The crop is slow to establish but grows vigorously as the season progresses. Being a legume, it fixes N from the atmosphere, and when combined with the above-average rainfall recorded at the trial sites in 2022, it grew a high level of biomass. This combination resulted in high levels of soil N being recorded in 2023 and 2024. It's not a cheap crop to establish, growers looking to implement this rotation should grow their seed.

If the opportunity presents itself, vetch could be sown dry in early April, but growers should never compromise seeding cash crops to plant vetch early in the season.

The economics of fallow in the context of the whole farm system warrants further discussion. In this project, the economics were determined using a gross margin analysis; this financial analysis method looks at cash returns. However, fallow is a rotation crop with benefits that cannot be easily measured in terms of cash benefits. Perhaps a gross margin analysis is the incorrect method to use when performing a financial analysis of fallow. Perhaps fallow should be considered a 'short-term asset' and a value recorded on the balance sheet of the farm business. Based on the results of this project, the author suggests fallow could be valued at $120/ha (0.4 t/ha increase in grain yield * $300/t wheat price). To a farming business in the LRZ, fallow as an asset could be worth $200,000 (average cropped area for a farm in LRZ = 5,500 ha, assuming 30% area fallow @ $120/ha).

CONCLUSION

If growers in the LRZ are thinking about fallow, their best option is to adopt the brown out practice. It stores the most soil water, increases soil N and allows growers to use different chemistry to control glyphosate resistant ryegrass.

Brown out does come at a cost, a cereal rotation will deliver the highest gross margin. However, when all the benefits of fallow are included, it does have a positive economic benefit to the whole farm business.

A missing gap in the research is optimising agronomy in the crop after fallow. Laconik, in partnership with a grower in the LRZ, has started researching this, and early results are promising. Based on the trials, the grower has reduced their use of compound fertiliser on wheat, sown on fallow, from 50 kg/ha to 25 kg/ha, a saving of $27/ha, a total saving to the grower of $135,000. On light soil types, the wheat seeding rate has increased from 50 kg/ha to 75 kg/ha to increase crop competition and reduce the adverse effects of weeds; the estimated benefit is $10/ha or $50,000 across the farm. As more research is required, changes have yet to be made to N fertiliser decisions. The hypothesis is that N needs to be applied much earlier to wheat crops in the LRZ than current practice, and we have trials underway in 2024 to capture this data.

REFERENCES

Planfarm Benchmarks (2022), Season 2022.