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UNDERSTANDING THE LONG TERM LEGACY OF LIME APPLICATION IN LRZ IN SOUTH WESTERN NSW IN FARMING SYSTEMS LANDSCAPE

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Charles Sturt University

GRDC INVESTMENT FROM NATIONAL GROWER NETWORK (AGG2506-001RTX)

This project is a collaboration with Jason Condon, CSU

Evaluating the Legacy Effects of Lime 2025

KEY POINTS

- **There was no interaction between lime and cultivation evident.**
- **Liming significantly increased lentil establishment, vigour, NDVI and increased lentil grain yield by 17% compared to no lime.**
- **Tillage, regardless of type, reduced lentil establishment and vigour scores but had no effect on NDVI at flowering or on lentil grain yield in 2025. No significant effects were observed among cultivation methods to a depth of 20 cm.**
- **Plus phosphorus treatments (either with or without micronutrients) resulted in significantly higher lentil vigour scores, NDVI at flowering, and grain yield compared with treatments receiving no phosphorus.**
- **After 4 years, and with lentils grown as part of the rotation, we are starting to see some economic benefits of liming, particularly in treatments that combined 6t/ha lime with appropriate nutrient inputs and were cultivated to 20 cm by chisel +offset.**

BACKGROUND

Soil acidity is a major constraint for grain growers in southwestern NSW, particularly for growers based in low rainfall regions. The soils are considered highly acidic (<5 pH), contain low organic carbon and have low water holding capacity. While some regions have responded positively to the application of lime, production responses in the LRZ are limited in short term studies. Due to the variability in crop response and the high costs of applying lime, growers are uncertain of the economic benefits for their farming system. Growers who attended the Griffith, Hillston and Lake Cargelligo NGN forums identified the gap of the benefits liming have on their cropping operations.

This investment completes a monitoring study that evaluates the long-term performance of various liming strategies on cropping systems that have highly acidic soils. The trial is utilising the existing NGN project AGG2206-001RTX - Lime response on acid, low rainfall, sandy soils of southwestern NSW trial site, which was established in 2022 as the foundation. Liming strategies include different rates of lime, application depths and incorporation methods. This is a fully replicated trial, with comprehensive segmented soil tests undertaken

in 2023, one year after lime and cultivation treatments were applied. Crop rotation was wheat 2022, canola 2023 and wheat 2024. In 2025 the site was sown to lentils as part of the rotation. The site is located at the Ag Grow Agronomy research farm, "Ridgetop," located in Beelbangera, 16 km northeast of Griffith.

This trial evaluates the long-term benefits of liming, measuring the crop performance and soil characteristics of various liming treatments and cropping rotations over a five-crop sequence. It will also measure long term economic performance of the treatments, ensuring growers are confident of the response before undertaking the expensive strategies on their farming operations.

This report covers trial results from the 2025 cropping season. For previous year's results on the Lime response on acid, low rainfall, sandy soils of southwestern NSW 2022-2024 project refer to https://www.aggrowagronomy.com.au/wp-content/uploads/2025/05/2024-Lime-Trial-Report.pdf

2025 TRIAL DETAILS

The lime legacy trial was established on the existing NGN project AGG2206-001RTX - Lime response on acid, low rainfall, sandy soils site in 2025, with lime and cultivation treatments applied in 2022. The full list of treatments included in the trial are shown in table 1.

As part of the paddock rotation the trial was sown to Hallmark lentils at 40 kg/ha on the 29th April 2025 with 120 kg/ha superphosphate applied to appropriate plots. The trial was rolled 27th May 2025. Trace element treatments were applied on 4th July to the appropriate plots in treatments 11 and 12.

As per commercial practice, appropriate pest, disease and weed control was undertaken pre-emergence and again in crop, with 2 timely fungicides applied. The trial was harvested 31st October 2025.

Table 1: The full list of treatments in lime trial (note: treatments 11 and 12 are split plots).

Trt #	Lime Rate (t/ha)	Cultivation Treatment	Nutrition
1	0	nil	*plus Phosphorus*
2	0	10 cm chisel + offset	*plus Phosphorus*
3	0	20cm chisel + offset	*plus Phosphorus*
4	0	20 cm chisel + offset twice	*plus Phosphorus*
5	0	rotary hoe	*plus Phosphorus*
6	3	nil	*plus Phosphorus*
7	3	10 cm chisel + offset	*plus Phosphorus*
8	6	20cm chisel + offset	*plus Phosphorus*
9	6	20 cm chisel + offset twice	*plus Phosphorus*
10	6	rotary hoe	*plus Phosphorus*
11a	0	rotary hoe	*Nil Phosphorus*
11b	0	rotary hoe	*Nil Phosphorus + Micro*
11c	0	rotary hoe	*plus Phosphorus + Micro*
12a	6	rotary hoe	*Nil Phosphorus*
12b	6	rotary hoe	*Nil Phosphorus + Micro*
12c	6	rotary hoe	*plus Phosphorus + Micro*

Seasonal Conditions 2025:

Conditions straight after harvest 2024 were wet, with 90mm falling in November and December, which topped up the soil profile. The first 4 months of 2025 were dry, with below average rainfall and above average temperatures. This trial was sown into moisture on 29th April, after 14mm on 25th April, and emerged evenly. Warm and dry conditions persisted into May, with some much-needed rain falling towards the end of the month, table 2. Follow up rain occurred mid-late June, before the crop accessed stored moisture.

With warmer, windy days and frosts impacting topsoil moisture, below average rainfall continued throughout June, July and August as drought conditions strengthened.

Much needed rain occurred in early September, setting up the crop. There was 166.5mm of growing season rainfall (GSR) from April–October (200.5mm GSR average) with 76mm of this rainfall from early/mid-September and October.

Table 2: 2025 Rainfall and Growing Season Rainfall (GSR) for the trial site, compared to long term rainfall taken at Griffith Airport.

MONTH	Ridgetop Rainfall 2025	Griffith Airport 2025	Griffith Airport Long Term (1958 to 2025)
January	4	4.4	36.3
February	18	23.6	28
March	32	25	35.3
April	*13.5*	*12.4*	*29.3*
May	*18*	*14.8*	*36.1*
June	*25*	*29*	*35.1*
July	*24.5*	*22.4*	*32.4*
August	*9.5*	*17*	*34.9*
September	*50.5*	*32.8*	*32.7*
October	*25.5*	*7.2*	*39.4*
November	13.5	21.2	36.3
December *	9.5	10.2	32.7
TOTAL	**243.5**	**220**	**408.5**
GSR (April - Oct)	***166.5***	***135.6***	***239.9***
** to 16th December*			

RESULTS AND DISCUSSION

Establishment, NDVI and grain yield were assessed. The significant main effects or interactions are reported below.

Cultivation type x +/- lime

There was no interaction of lime and cultivation on establishment, vigour, NDVI and grain yield.

Establishment and Crop Vigour: Establishment and crop vigour were assessed in June at the 6-8 node stage. Both were scored from 0-9, with 0 indicating poor establishment or poor vigour and 9 indicating very even establishment or good vigour. The average establishment score of the trial was 7.9 and the average vigour score was 7.6.

Lime had a significant effect on both establishment and vigour, with establishment and vigour significantly greater with the addition of lime, figures 1 and 2. Likewise cultivation alone also had a significant effect on establishment and vigour score, with any type of tillage decreasing both establishment and vigour of lentils.

Figure 1: Establishment scores for lime trial, with significant lime and cultivation treatment effect.

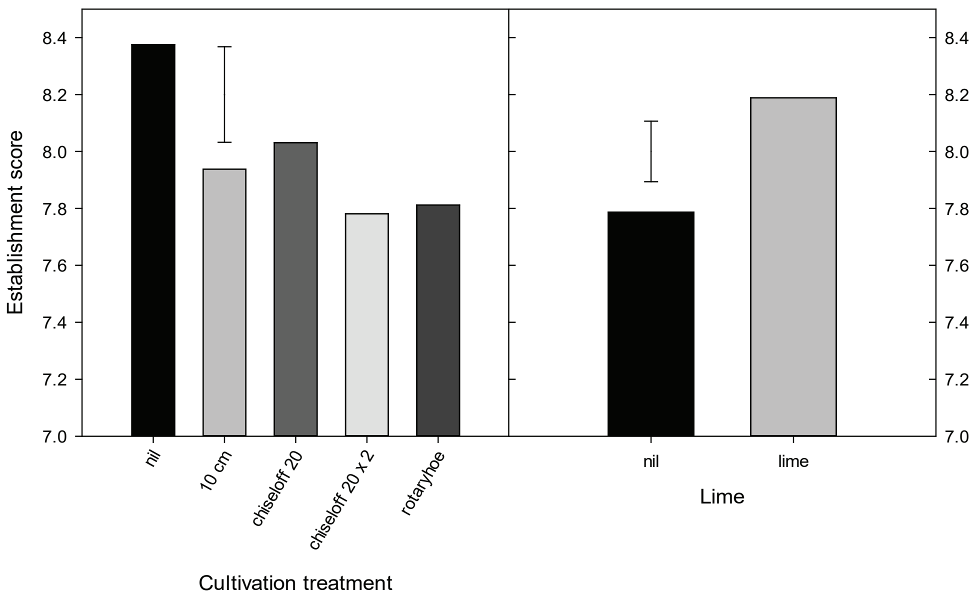
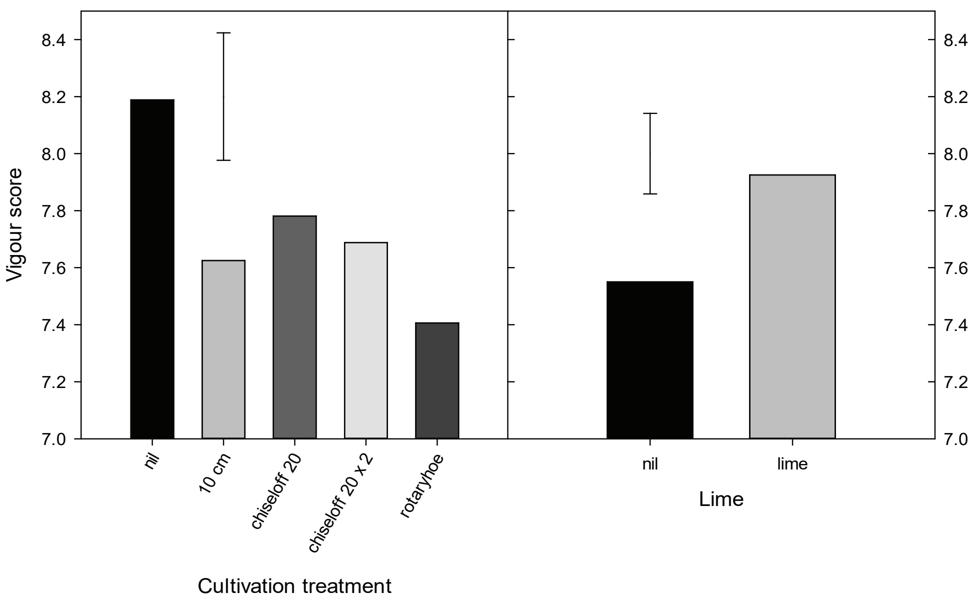


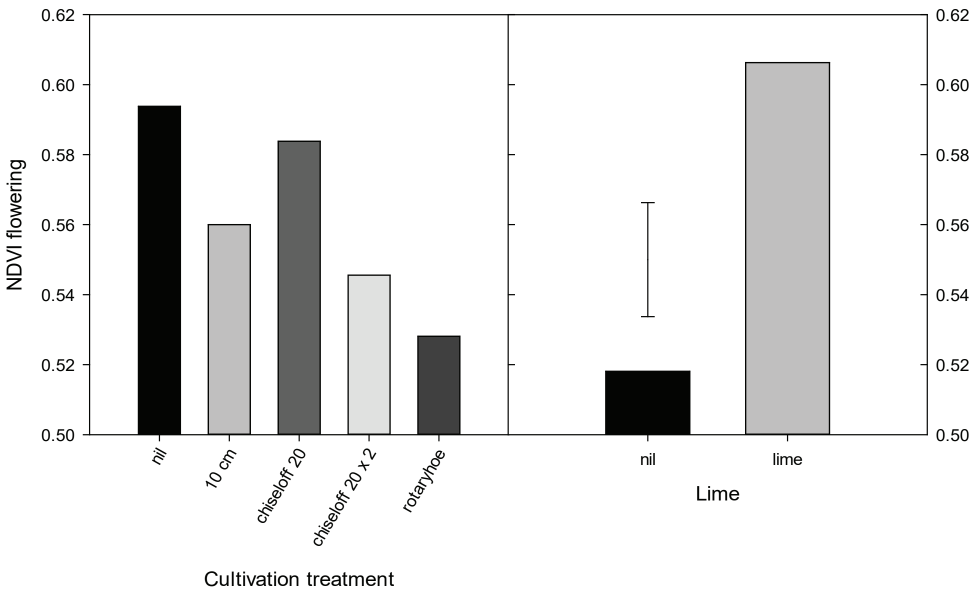
Figure 2: Vigour scores for lime trial, with significant lime and cultivation treatment effect.



NDVI at flowering: NDVI was measured using a handheld GreenSeeker crop sensor, with an NDVI reading taken at flowering. The average NDVI of the trial was 0.53.

NDVI indicated a significant main effect for lime, with the addition of lime having a significantly greater NDVI than no lime, figure 3. There was no effect of cultivation on NDVI at flowering.

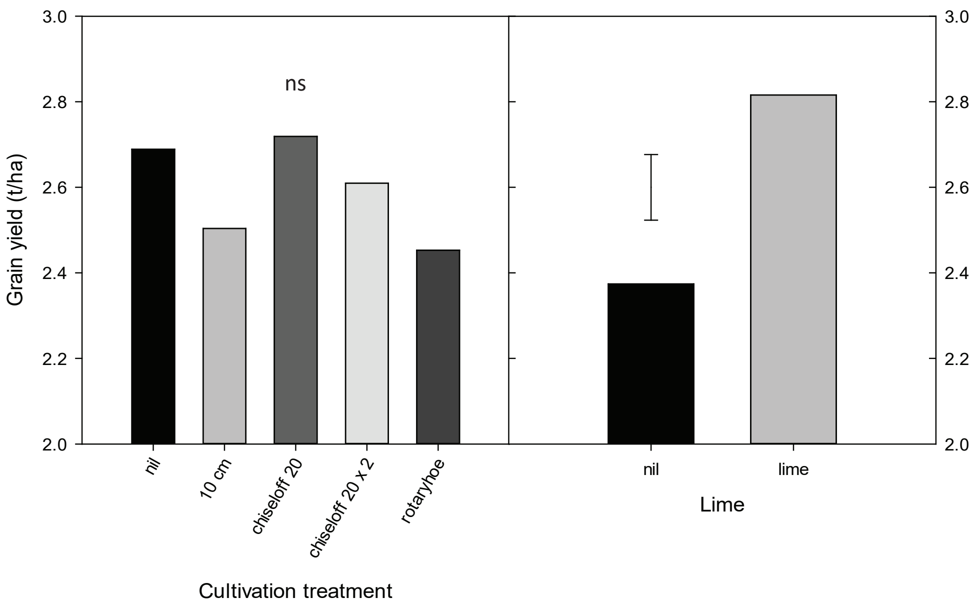
Figure 3: NDVI at flowering of the lime trial, cultivation and lime treatment effects.



Grain yield: The average grain yield of the trial was 2.4 t/ha.

There was a significant main effect for lime application. Lime caused a significant increase in grain yield, with yield increasing 17% with the addition of lime, figure 4. There was no significant effect of cultivation on grain yield.

Figure 4: Grain yield of the lime trial, cultivation and lime treatment effects.



0 and 3 t lime/ha x +/- cultivation to 10cm

There was no interaction of 0t/ha and 3t/ha lime when either surface applied or cultivated to 10cm on establishment, vigour, NDVI and grain yield.

Tillage significantly lowered establishment and vigour scores compared to no tillage, whilst the addition of lime at 3t/ha significantly increased establishment score compared to no lime, figures 5 and 6. Lime at 3 t/ha significantly increased NDVI at flowering compared to no lime, whilst there was no difference in NDVI between no tillage and tillage to 10cm, figure 7.

Figure 5: Cultivation to 10cm and lime treatment effects on establishment score.

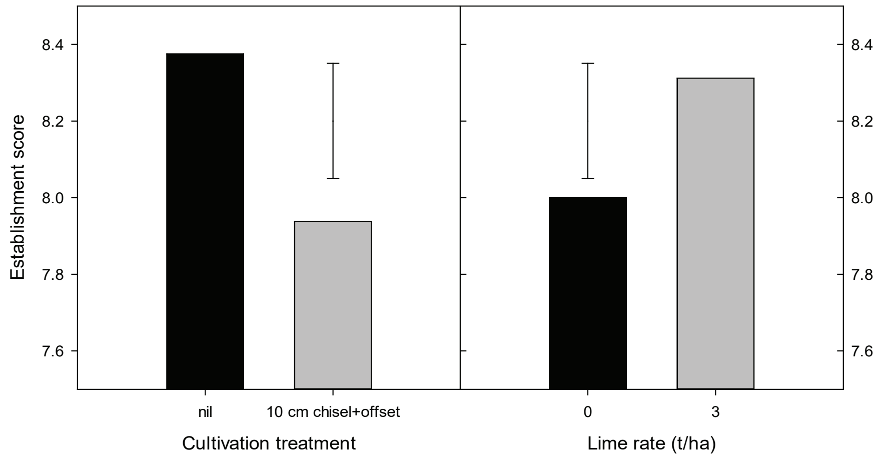


Figure 6: Cultivation to 10cm and lime treatment effects on vigour score.

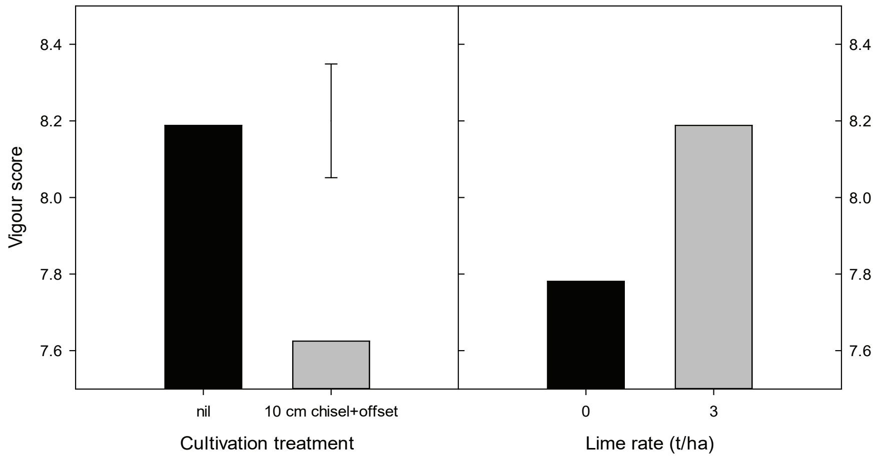
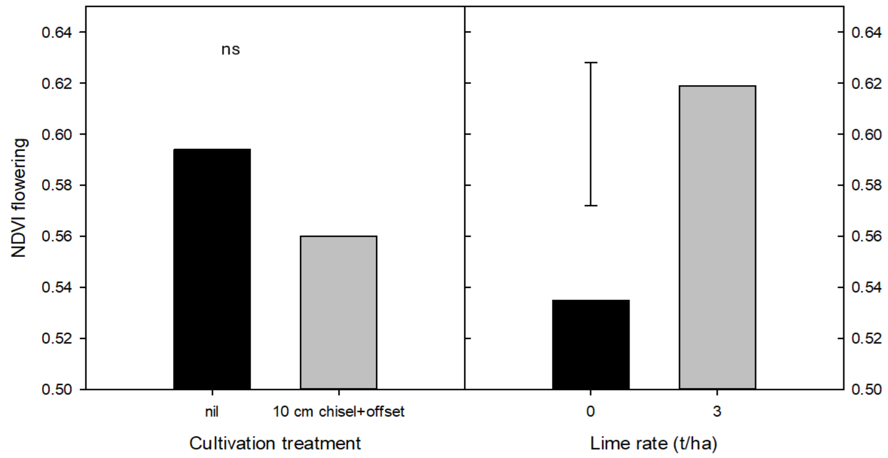
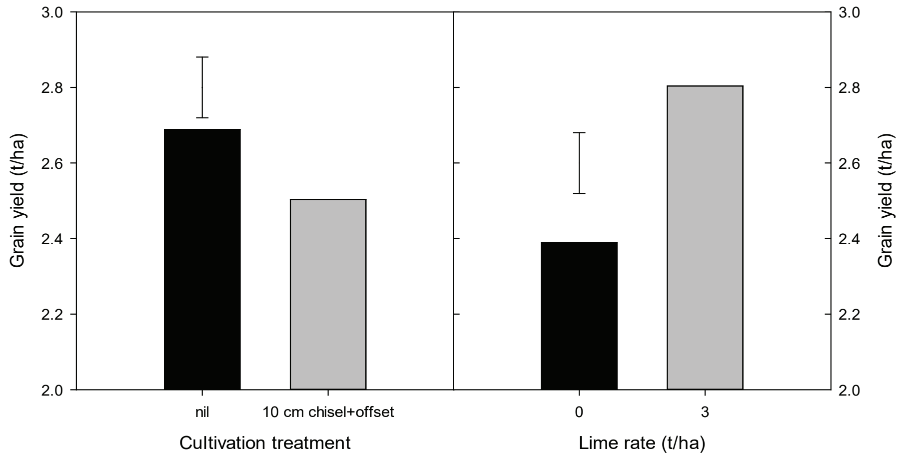


Figure 7: Cultivation to 10cm and lime treatment effects on NDVI.



Grain yield of lentils was significantly lower with cultivation to 10cm compared to no cultivation, figure 8. The addition of 3 t/ha lime significantly increased lentil yield compared to no lime.

Figure 8: Cultivation to 10cm and lime treatment effects on grain yield.



6 t lime/ha x cultivation type to 20cm

There were no interactions for 6t/ha lime and deep cultivation. There were also no significant effects between cultivation methods (chisel plough and rotary hoe) to a depth of 20cm. The application of 6t/ha lime significantly increased establishment and vigour score, NDVI at flowering and grain yield compared to no lime, figures 9 to 12.

Figure 9: Cultivation to 20cm and 6t/ha lime treatment effects on establishment.

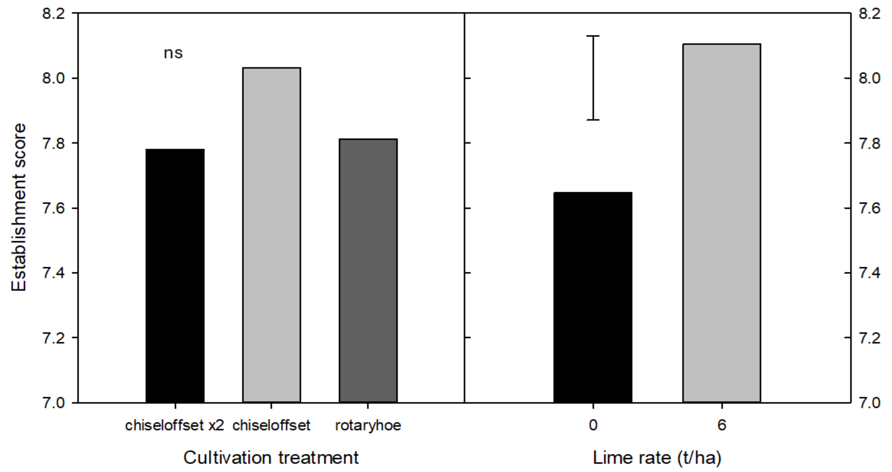


Figure 10: Cultivation to 20cm and 6t/ha lime treatment effects on crop vigour.

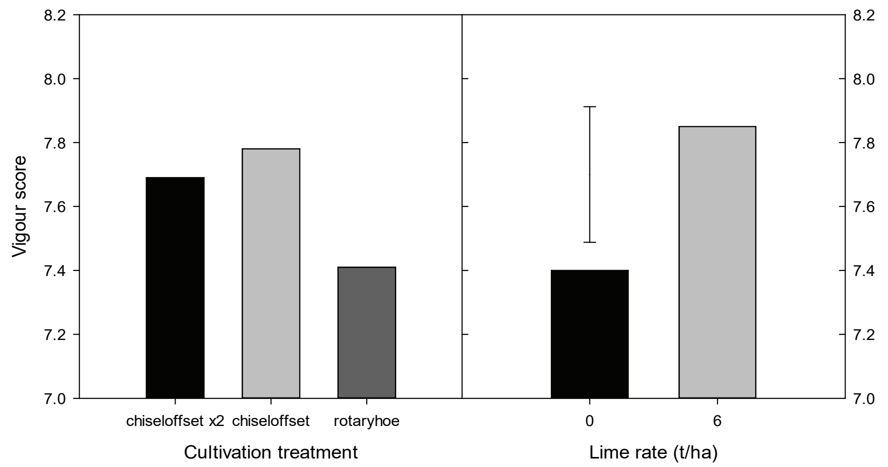


Figure 11: Cultivation to 20cm and 6t/ha lime treatment effects on NDVI at flowering.

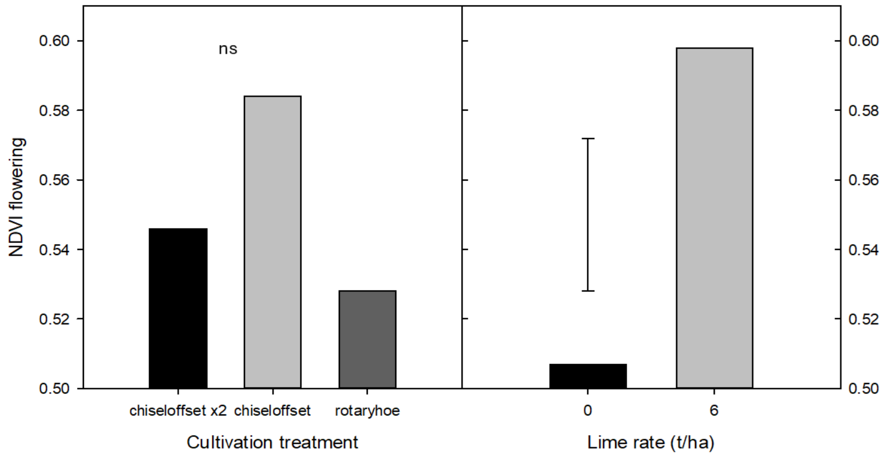
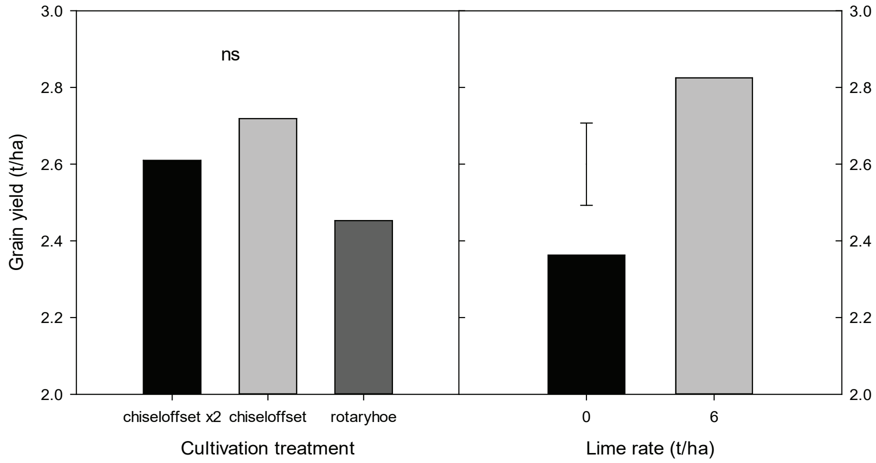


Figure 12: Cultivation to 20cm and 6t/ha lime treatment effects on grain yield.



6 t lime/ha x P x micronutrients

The nutrient component of the trial consisted of treatments which were all incorporated with a rotary hoe. There were no interactions between lime, P or micronutrient applications.

Figures 13 to 16 show the effect of 6t/ha lime, P and micronutrients on establishment, vigour, NDVI and grain yield. The addition of 6t/ha lime significantly increased establishment score, vigour score, NDVI and grain yield compared to no lime for the micronutrient treatments.

There were no significant effects of P or micronutrients for establishment score, figure 13. The addition of P caused significantly higher vigour scores, NDVI at flowering and grain yield compared to no P treatments.

Figure 13: 6t/ha lime, P and micronutrient effects on establishment.

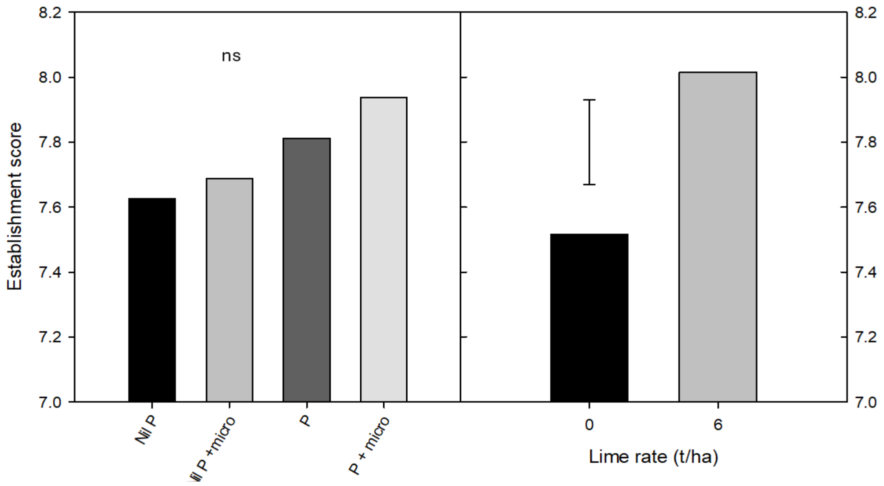


Figure 14: 6t/ha lime, P and micronutrient effects on crop vigour.

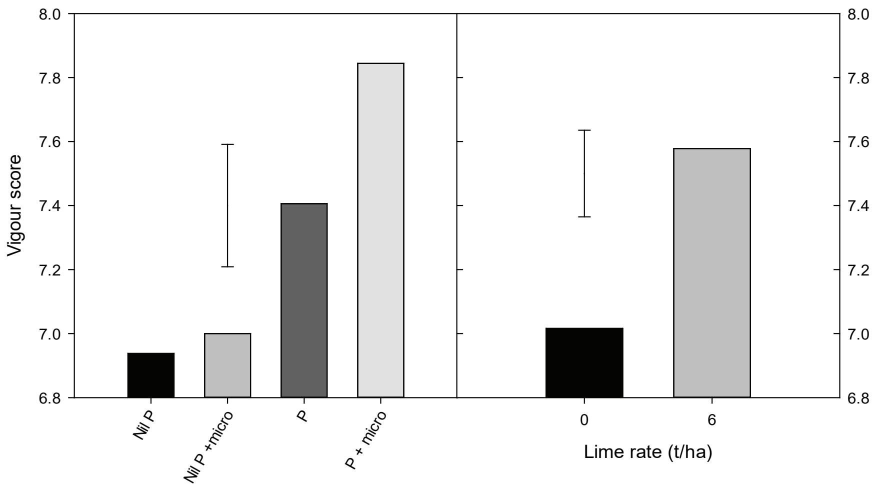


Figure 15: 6t/ha lime, P and micronutrient effects on NDVI at flowering.

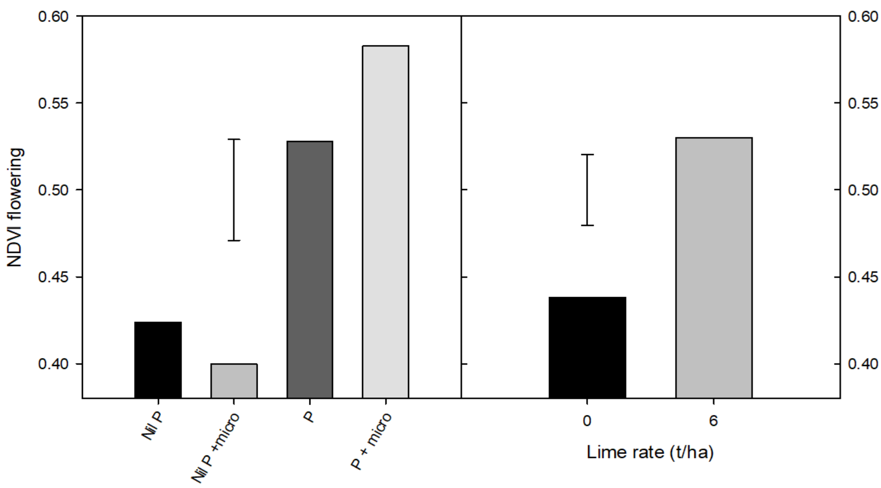
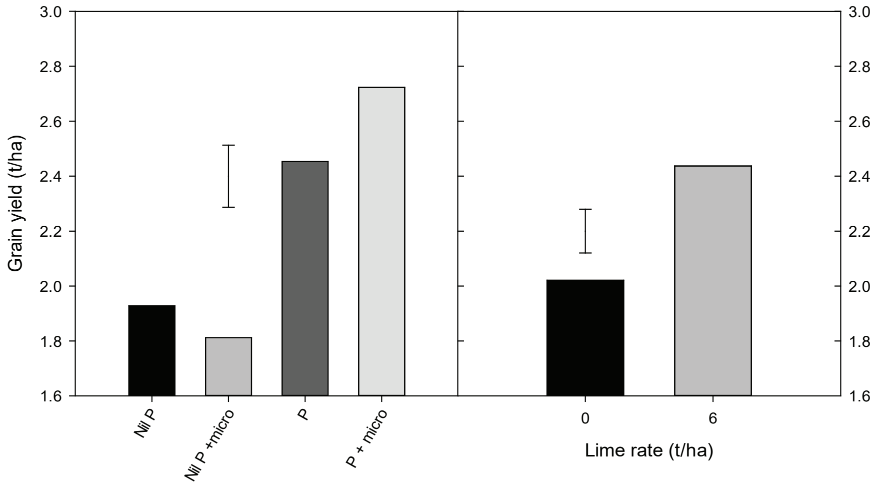


Figure 16: 6t/ha lime, P and micronutrient effects on grain yield.



Nodulation:

A non replicated nodulation score was carried out on select treatments in the trial to gauge their effect on nodulation, using the Yates et al scoring system. Nodulation was scored from 0-8, with a score of 4 or more considered adequate nodulation.

Treatments without lime or without P generally had poorer nodulation, table 3. Treatments which received 6t lime and P had the highest nodulation scores, figure 17.

Table 3 Indicative nodulation score taken at flowering, August 2025.

	Treatment ID	Nodule score	*Description*
1	0|nil|P	2-2.5	*scarce*
6	3|nil|P	3	*moderate*
7	3|10 cm chisel + offset|P	4	*adequate*
8	6|20cm chisel + offset|P	5	*ample*
10	6|rotary hoe|P	5.5	*ample*
11	0|rotary hoe|Nil P	1	*rare*
12	6|rotary hoe|Nil P	3.5-4	*adequate*

Figure 17: Lentil nodulation - treatments 1, 7, 10 and 11 (top to bottom), August 2025.

ECONOMICS

Profit for each treatment was calculated using only the costs directly attributable to that treatment. These included expenses above the standard annual paddock costs, such as cultivation, liming, and fertiliser applications. Revenue, costs, and profit for each treatment in 2025 and cumulatively after four years are presented in Table 4.

After 4 years, and with lentils grown as part of the rotation, we are starting to see the benefits of liming. With lentil grain yields significantly greater with lime, due to their sensitivity to acid soils, we are starting to recuperate the upfront cost of lime application on these treatments.

Treatment 3 again generated the highest profit above the control (Treatment 1), with a return of $423, this treatment involved deep cultivation to 20 cm with offsetting, no lime application, and phosphorus applied at sowing. Other treatments, without lime, to produce positive profits relative to the control after four years were treatments 4 (no lime, deep cultivation with two offset passes and phosphorus) with a return of $28 and treatment 11c with a return of $198 (rotary hoe with phosphorus and micronutrients).

Treatments that received the higher lime rate (6 t/ha) in combination with phosphorus generally produced higher grain yields and total revenues compared with treatments without lime, regardless of cultivation method. However, for the first time treatments 8 and 9, both of which received 6 t/ha of lime and were deep cultivated to 20 cm with offsetting, also returned a positive profit with $96 and $33 respectively.

The treatments receiving 3 t/ha of lime resulted in negative profits after four years. Among these, treatment 6 (without cultivation) was less profitable than treatment 7, which had a shallow cultivation.

In the nutrient trial, the addition of micronutrients without phosphorus resulted in lower revenues irrespective of lime application. Treatment 11b (no lime or phosphorus, rotary hoed with micronutrients) recorded the lowest revenue and the lowest profit (-$1,245). This was followed by treatments 12a (-$871) and 12b (-$851), both of which had 6 t/ha of lime without phosphorus.

Table 4: Revenue, treatment costs and profit of each treatment after 4 years (2022-2025) compared to the control.

		2025 Lentils			2022 to 2055			
Trt No.	TREATMENT	Lentil Grain yield (kg/ha)	Revenue *based on lentils $600 on farm	Treatment Cost ($)	Total Revenue ($)	Total Treatment Cost ** ($)	Revenue *minus* Treatment Costs ($)	Profit (compared to control)
1	0|nil|P	2556	1533	48	6029	304	5725	$ -
2	0|10 cm chisel + offset|P	2222	1333	48	5943	374	5569	-$ 156
3	0|20cm chisel + offset|P	2629	1577	48	6537	389	6148	$ 423
4	0|20 cm chisel + offest twice|P	2329	1397	48	6181	429	5752	$ 27
5	0|rotary hoe|P	2200	1320	48	5944	374	5570	-$ 155
6	3|nil|P	2822	1693	48	6033	641	5392	-$ 333
7	3|10 cm chisel + offset|P	2786	1671	48	6305	711	5594	-$ 131
8	6|20cm chisel + offset|P	2876	1726	48	6862	1041	5821	$ 96
9	6|20 cm chisel + offest twice|P	2892	1735	48	6839	1081	5758	$ 33
10	6|rotary hoe|P	2706	1624	48	6577	1026	5551	-$ 174
11a	0|rotary hoe|Nil P	1698	1019	0	5422	70	5352	-$ 373
11b	0|rotary hoe|Nil P + micro	1499	899	36	4729	250	4479	-$ 1,245
11c	0|rotary hoe|P + micro	2687	1612	84	6476	554	5922	$ 198
12a	6|rotary hoe|Nil P	2157	1294	0	5576	722	4854	-$ 871
12b	6|rotary hoe|Nil P + micro	2124	1274	36	5776	902	4874	-$ 851
12c	6|rotary hoe|P + micro	2759	1655	84	6665	1206	5459	-$ 266

***Costs are based on actual paddock costs; Treatment costs are those above the standard paddock costs of $767/ha 2022, $656/ha 2023, $718/ha 2024 and $630/ha 2025 are the costs attributed to the actual treatment.*

Cultivation costs (2022) include: *Offset $40/ha, Shallow cultivation $30, Deep cultivation $45, Rotary hoe $70*

Other Input costs include: *2022 Lime $105/t plus $22/ha spread; 2022 MAP $1550/t plus $10/ha application; 2023 Superphosphate $400/t plus $10/ha application; 2024 DAP $1300/t plus $10/ha application; 2025 Superphosphate $400/t plus $10/ha application; Micronutrients $28/ha plus $8/ha application*

DISCUSSION:

After four years, lime is starting to pay for itself. Lime has consistently improved crop establishment and early vigour, increased NDVI, and resulted in higher grain yield compared with no lime. Lentils are particularly sensitive to acidic soils and in the 2025 lentil crop, liming increased grain yield by 17% compared with no lime. As a result, the upfront costs associated with lime application are starting to be recovered, particularly in treatments that combined lime with appropriate nutrient inputs.

Treatments that received the higher lime rate (6 t/ha) in combination with phosphorus generally produced higher grain yields and total revenues than treatments without lime, regardless of cultivation method. Although these returns remain modest, they indicate that the productivity gains from higher lime rates are beginning to outweigh the substantial initial investment, particularly when combined with deep cultivation and adequate phosphorus.

Tillage of any type was found to reduce establishment, but it did not affect final grain yield. In contrast, lime delivered clear benefits across establishment, vigour, canopy development, and yield, confirming its value as a long-term investment in soil acidity management.

Results from the nutrient component of the trial have further emphasised the importance of phosphorus in driving profitability. The addition of micronutrients without phosphorus consistently resulted in lower revenues, irrespective of lime application.

Repeat comprehensive soil tests will be carried out before sowing in 2026 and should provide further data on the legacy of lime in our soils, including the impact of lime on soil pH and soil P reserves.

ACKNOWLEDGEMENTS

This GRDC NGN initiative is led by

Ag Grow Agronomy and Research in collaboration with Jason Condon, CSU.

AgGrow AGRONOMY + RESEARCH

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