AgGrow
AGRONOMY + RESEARCH

LIME RESPONSE ON ACID, LOW RAINFALL, SANDY SOILS OF SOUTHWESTERN NSW

GRDC Investment from National Grower Network (AGG2206-001RTX)

2022-2025

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

This project is a collaboration with Jason Condon, CSU.

Charles Sturt University

2024 KEY POINTS

Cultivation x lime:

- **The crop performed better when cultivation to 20 cm occurred by chisel +offset. This outperformed rotary hoe and cultivation to 10cm.**
- **The addition of lime increased yield (0.24 t/ha) compared to un-limed plots, although the increase in yield caused a decrease in grain protein.**
- **There was no interaction between lime and cultivation evident. except for grain test weight.**
- **If only cultivating to 10 cm, liming (3 t/ha) produced optimal yield, but grain protein was reduced.**

Micronutrients and P:

- **The soil was responsive to P fertiliser but not micronutrients.**
- **The addition of P increased plant vigour, NDVI, grain test weight, and grain yield.**
- **An interaction of lime and micronutrients was evident for vigour, with better crop vigour in plus P, plus lime compared to all other treatments.**
- **Where lime was applied there were lower screenings in treatments without P, compared to treatments with no P and no lime.**

Economics:

- **After 3 years there has been no economic advantage of lime. Liming is producing greater revenue; however profit has been substantially lower than nil lime.**
- **A pulse crop is to be grown in the rotation in 2025 and should further tease out treatment differences.**

BACKGROUND

This project is a GRDC National Grower Network (NGN) investment. The project came about as there was a need to validate the issue of acid soils that are anecdotally unresponsive to lime in southwestern NSW, so that crop yield gaps can be reduced. The site is located at the Ag Grow Agronomy research farm, “Ridgetop,” located in Beelbangera, 16 km northeast of Griffith.

The trial was set up to measure the efficacy of applied lime on grain yield and profitability; differences between incorporation methods; differences between incorporation depths and the impact on phosphorous uptake efficiency.

Treatments included 3 lime rates (nil lime, 3t/ha lime and 6t/ha lime); 5 cultivation treatments (nil cultivation, 10 cm chisel + offset, 20 cm chisel + offset, 20 cm chisel + offset twice and rotary hoe; and 4 phosphorus (P) treatments (Plus P, Nil P, Plus P + Micro and Nil P + Micro).

This report covers trial results from the 2024 cropping season and cumulative data from 2022-2024. For previous year’s results and more detailed background of this project and set up please refer to: https://www.aggrowagronomy.com.au/wp-content/uploads/2024/02/Lime-Project-Trial-Report.pdf

2024 TRIAL DETAILS

The trial was established in 2022, with lime and cultivation treatments applied the first year. 2024 was the third year of the trial, with wheat sown in 2022 and canola sown in 2023.

In 2024 it was sown to Valiant wheat @ 35 kg/ha with 80 kg/ha DAP applied to appropriate plots. 100 kg/ha of urea was spread early April, and it was topdressed with 150 kg/ha of Urea in July. Trace element treatments were applied on 18th June 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 3 timely fungicides applied. The trial was harvested 19th November 2024.

Seasonal Conditions 2024:

The 2024 season began strongly, with good soaking rains in early April. Although a dry spell followed, beneficial rainfall in mid-May led to very wet conditions, allowing crops to establish well. This promising start, categorised as decile 8 to 10, set the season up positively (see Table 1).

However, below-average rainfall persisted across much of the area throughout winter, with warm, dry conditions into August. By September, conditions were tightening, culminating in a widespread severe frost in mid-September. On September 16, temperatures at Griffith Airport dropped as low as -2.1°C, with even lower temperatures recorded in other areas, remaining below 0°C for much of the night. Rainfall in the last week of September provided some relief.

In mid to late October, storms with strong winds and hail caused further crop damage in some regions.

Table 1: 2024 Rainfall and Growing Season Rainfall (GSR) for "Ridgetop" Beelbangera, compared to long term rainfall taken at Griffith Airport.

MONTH	Ridgetop Rainfall 2024	Griffith Airport 2024	Griffith Airport Long Term (1958 to 2024)
January	83.5	84.4	36.8
February	18	24.6	28
March	15	14	35.4
April	*48*	*53.2*	*29.6*
May	*104*	*94.8*	*36.1*
June	*11.5*	*16*	*35.1*
July	*14*	*19.2*	*32.4*
August	*22*	*28.6*	*34.9*
September	*22*	*22.4*	*32.7*
October	*24.5*	*8.4*	*39.9*
November	67	47.4	36.4
December *	8	11	32.6
TOTAL	**437.5**	**424**	**409.9**
GSR (April - Oct)	*246*	*242.6*	*240.7*

** to 6th December*

RESULTS AND DISCUSSION

Establishment, NDVI, grain yield and grain quality, were assessed and statistically analysed using Genstat.

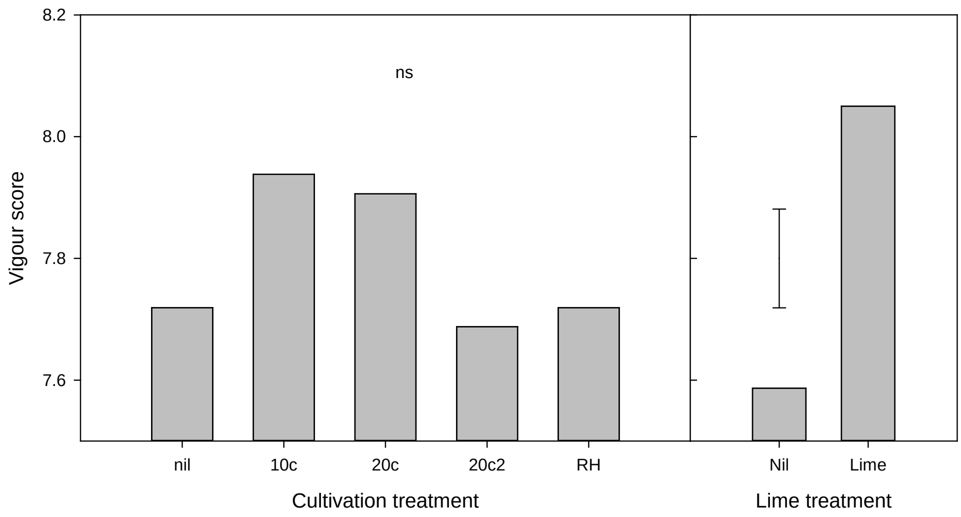
The significant main effects or interactions for 2024 are reported below, and include lime by cultivation effects, a comparison of surface only and 10 cm cultivation and the nutrient trial component.

2024 - Lime x cultivation effects

Establishment and Vigour: Establishment was evaluated around 5 leaf, with each plot scored from 0 to 9, where 0 indicated poor establishment and 9 indicated very even establishment. There were no significant differences in establishment scores between treatments, with an average establishment score of 8.1.

Vigour was scored at the same time, using a similar system. There was no interaction of lime and cultivation for vigour score. The main effect of lime was the only significant effect, with lime causing a significant increase in vigour score compared to where no lime was applied, figure 1. The average vigour score of the trial was 7.8.

Figure 1: Vigour scores for lime trial, with significant lime treatment effect.

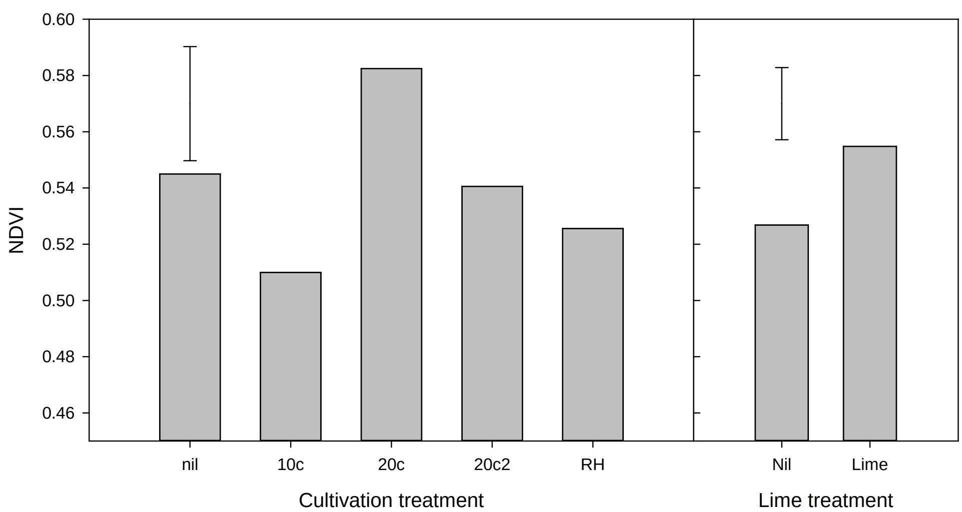


NDVI: NDVI measurements were obtained using a handheld GreenSeeker crop sensor, with two readings taken, mid/late tillering and before flowering.

The average NDVI of the first reading was 0.54. The early NDVI indicated a significant main effect for cultivation, with the greatest NDVI in the 20 cm chisel +offset treatment, figure 2. There was also a significant main effect for lime application for early NDVI. The flowering NDVI showed similar trends to early NDVI, but no significant differences existed between treatments by that time. The average flowering NDVI was 0.64.

There were no significant interactions between lime and cultivation for NDVI at either time period.

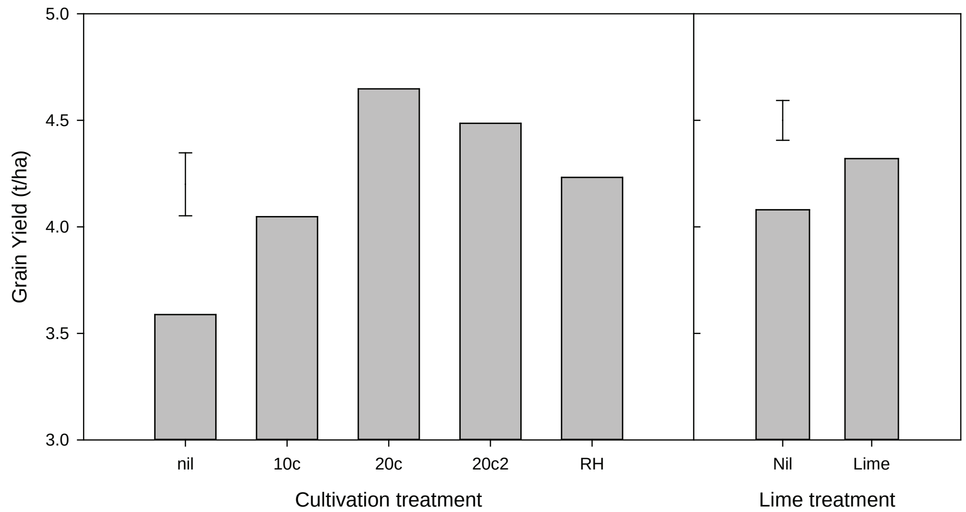
Figure 2: Early NDVI of the lime trial, cultivation and lime treatment effects.



Grain yield: The average grain yield of the trial was 4.2 t/ha. A significant main effect for cultivation existed. Cultivation significantly increased grain yield by 1 t/ha compared to a non-cultivated control, figure 3. Chisel + offset to 20 cm had the greatest grain yield, regardless of number of passes with offset (ie one pass as optimal). This treatment yielded 0.6 t/ha more than 10 cm cultivation. The Rotary hoe treatment was not significantly different to 10 cm chisel + offset.

A significant main effect for lime application also existed. Lime caused a significant increase in grain yield, yielding an extra of 0.24 t/ha compared to no lime application. There was no significant interaction of lime and cultivation.

Figure 3: Grain yield of the lime trial, cultivation and lime treatment effects.



Grain Quality:

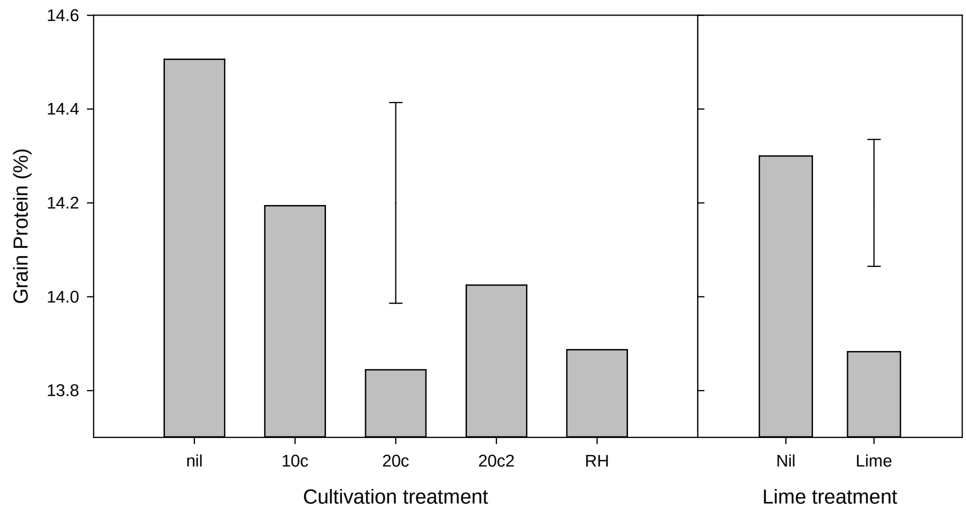
Protein: The average grain protein of the trial was 14.1%. A significant main effect for cultivation existed. Cultivation to 20 cm caused a significantly lower protein percentage than the no cultivation (incorporate by sowing) treatment, figure 4. There were no differences between cultivation treatments (chisel+offset 10 cm, 20 cm and rotary hoe).

A significant main effect for lime application existed. Lime caused a significant decrease in grain protein compared to no lime application. This corresponded with a significant increase in yield due to lime.

There was no significant interaction of lime and cultivation for grain protein.

Screenings: There were no significant effects for screenings.

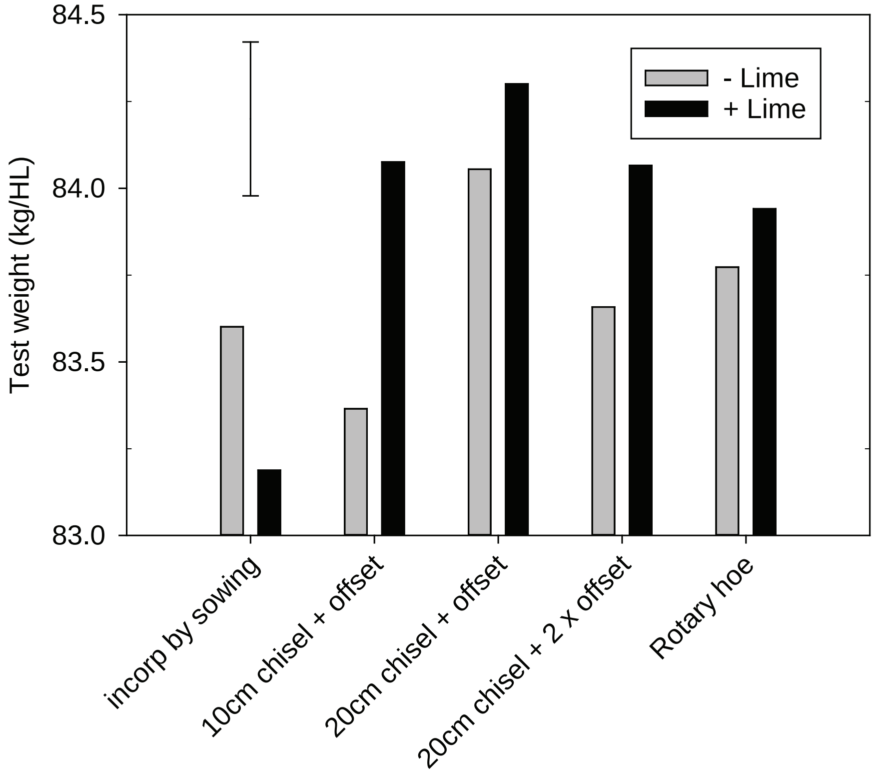
Figure 4: Grain protein of the lime trial, cultivation and lime treatment effects.



Test weight: The average test weight of the trial was 83.8 kg/HL. A significant interaction of lime and cultivation method occurred for grain test weight (kg/HL), figure 5.

Liming when cultivating with chisel + offset to 10 cm increased test weight compared to no lime plots. In the absence of lime, cultivating with chisel+offset once increased test weight compared to cultivation to 10 cm. When lime was applied, any form of cultivation increased test weight compared to the incorporate by sowing (surface applied) treatment.

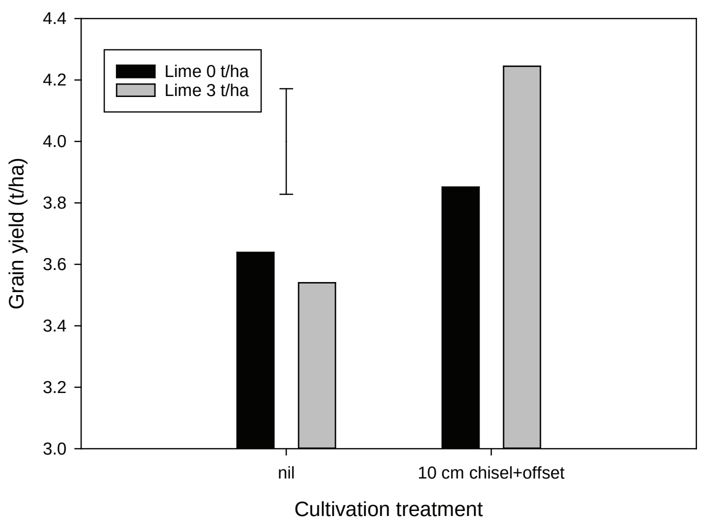
Figure 5 Test Weight of the lime trial, cultivation and lime treatment effects.



2024 comparison of only surface and 10 cm cultivation

Grain yield: The average grain yield of the nil cultivation treatment was 3.59 t/ha and the 10 cm chisel + offset treatment was 4.05 kg/ha. Grain yield significantly increased when lime was incorporated to 10 cm with chisel+offset, figure 6. There was no yield benefit from lime at 3 t/ha if not incorporated.

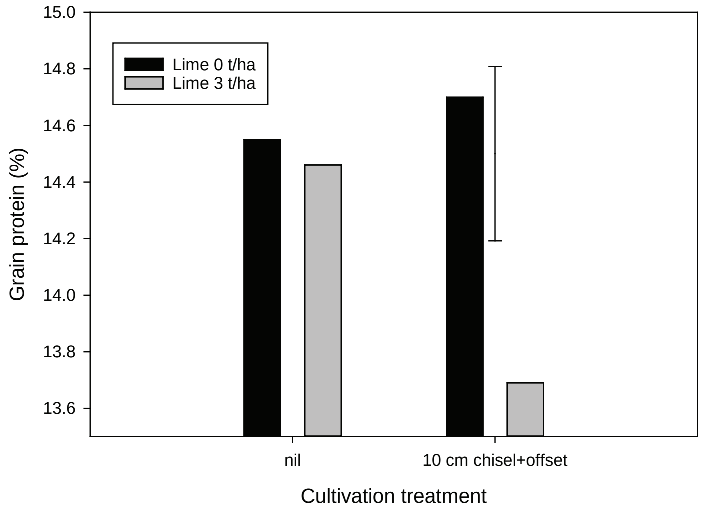
Figure 6: Grain yield of the lime trial, 3t/ha lime for surface and 10cm cultivation.



Grain Quality:

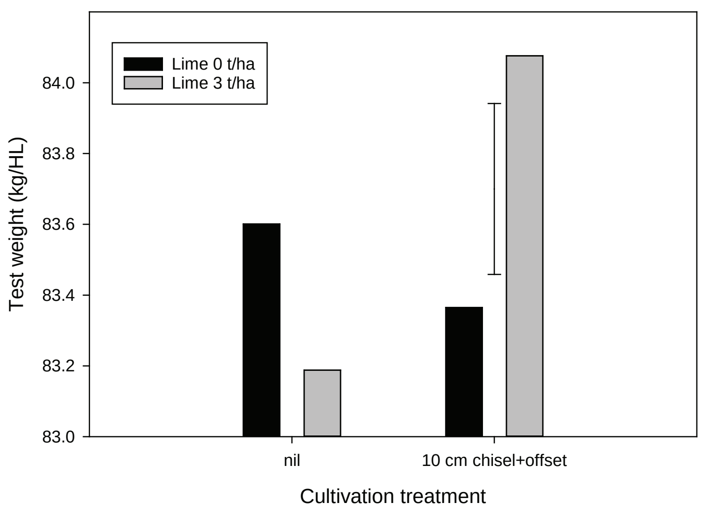
Protein: Grain protein significantly decreased when lime was incorporated to 10 cm with chisel+offset, figure 7. There was no difference in grain protein of un-limed treatments or from lime at 3 t/ha if not incorporated.

Figure 7: Protein of the lime trial, 3t/ha lime for surface and 10cm cultivation.



Test Weight: Grain test weight significantly increased when lime was incorporated to 10 cm with chisel+offset compared to surface applied (incorporate by sowing) or cultivation to 10 cm without lime addition, figure 8 There was no difference in grain test weight between other treatments.

Figure 8: Test weight of the lime trial, 3t/ha lime for surface and 10cm cultivation.



2024 Nutrient Trial

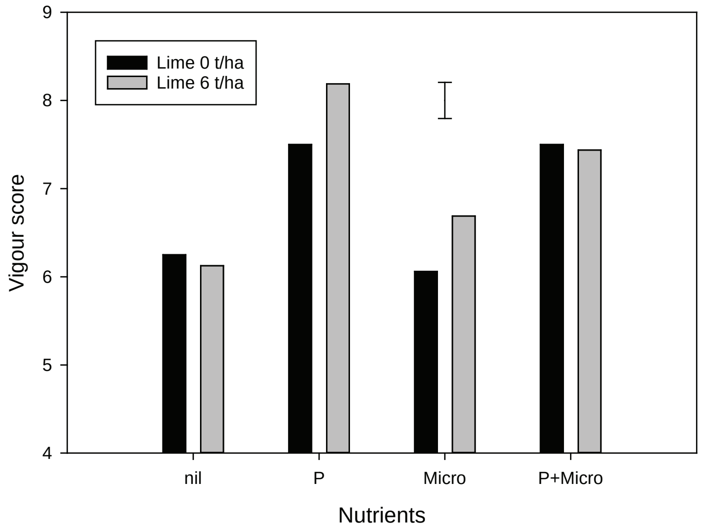
The nutrient component of the trial consisted of treatments which were all incorporated with a rotary hoe.

Establishment and Vigour: There were no significant differences in establishment scores due to treatment as the main effect or the interaction between lime and micronutrient application.

A significant interaction occurred for lime and nutrient treatment for vigour scores. The soil was responsive to P addition. Plants receiving P had a significantly higher vigour score than those without P.

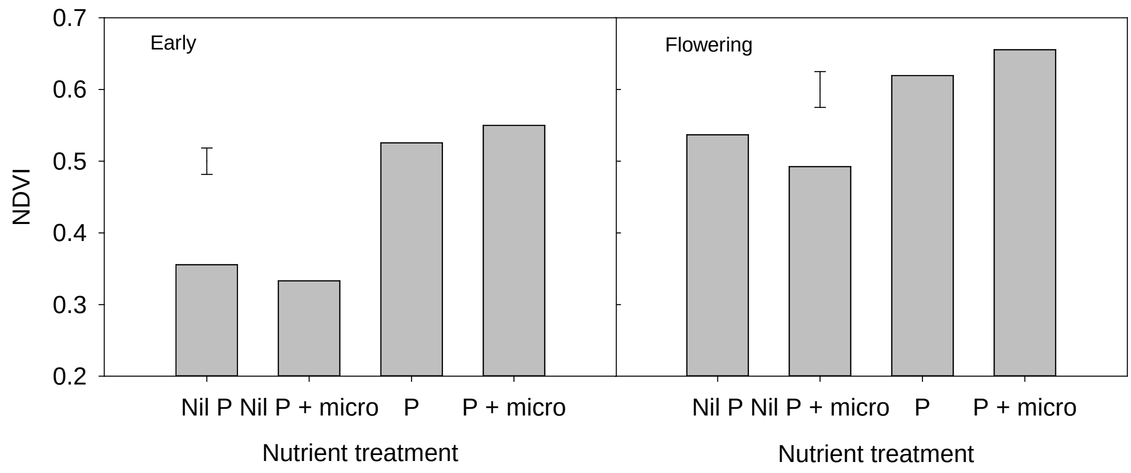
In the presence of lime, vigour score of plants +P with micronutrients was significant less than + P without micronutrients, figure 9. This difference did not occur in the absence of lime. In the presence of lime, the addition of micronutrients had a significantly higher vigour score compared to lime without micronutrients.

Figure 9: Vigour scores for nutrient trial, plus and minus lime.



NDVI: At both measurement times, the addition of P caused significantly greater NDVI values than treatments not receiving P, figure 10. Regardless of the presence or absence of P, the addition of micronutrients did not cause significant differences in NDVI.

Figure 10: NDVI early and at flowering for nutrient trial.

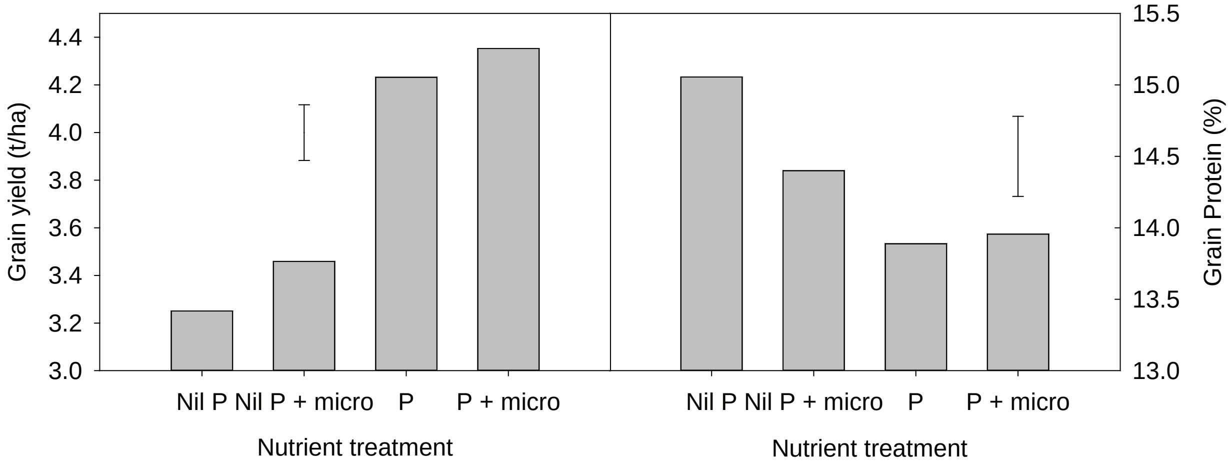


Grain Yield and Protein:

The addition of P caused significantly greater grain yield than treatments not receiving P, figure 11. Regardless of the presence or absence of P, the addition of micronutrients did not cause significant differences in yield.

The addition of either P or micronutrients caused significantly less grain protein compared to the untreated control. No significant differences existed in grain protein between plots treated with P or micronutrients.

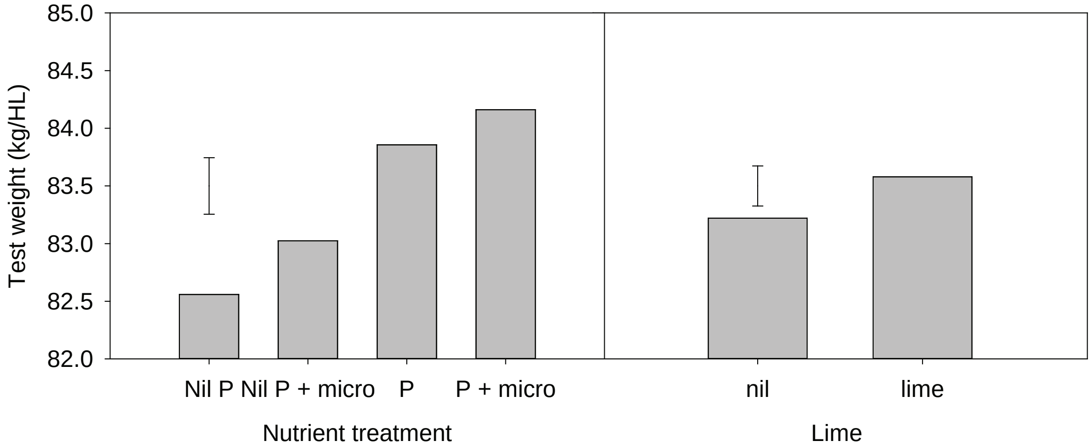
Figure 11: Grain yield and protein for nutrient trial.



Quality:

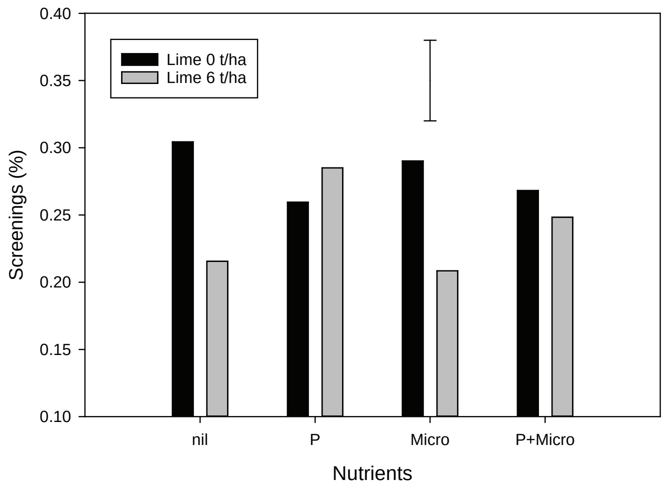
Test weight: The addition of P caused significantly greater test weight than treatments not receiving P, figure 12. Regardless of the presence or absence of P, the addition of micronutrients did not cause significant differences in test weight. The addition of lime caused significantly greater test weight compared to the un-limed treatments.

Figure 12: Test weight for nutrient trial, for nutrient treatment and lime.



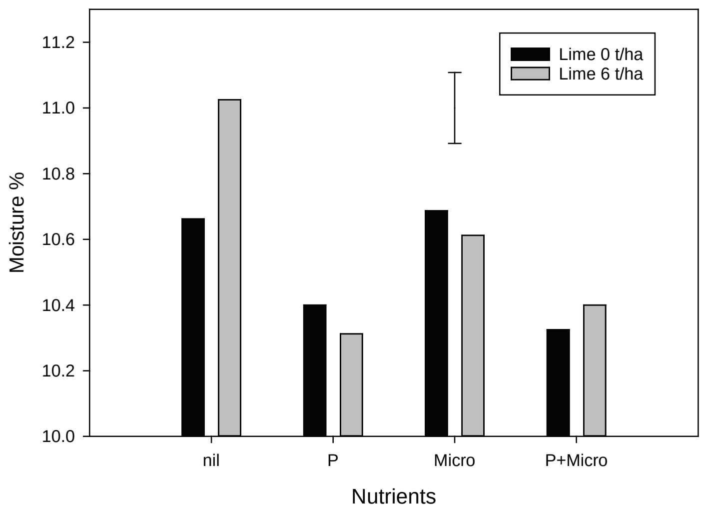
Screenings: In the absence of lime, the addition of micronutrients had no significant effect on screenings, figure 13. The addition of lime caused significantly lower screenings in treatments not receiving P addition.

Figure 13: Screenings for nutrient trial, plus and minus lime.



Grain Moisture: Regardless of liming, the addition of P caused a significant decrease in grain moisture percentage, figure 14. In the absence of micronutrient or P, the addition of lime caused significantly more grain moisture compared to all treatments.

Figure 14: SGrain moisture at harvest for nutrient trial, plus and minus lime.



ECONOMICS

Profit for each treatment was calculated based on the costs attributed to each treatment only, ie: treatment costs are those costs above the standard paddock costs each year and include any cultivation, liming and fertiliser cost for each treatment.

The profit of each treatment after 3 years, compared to the control, is shown in table 2. The treatment which has the greatest profit, above the control (treatment 1), is treatment 3 ($380). Treatment 3 had no lime applied and was deep cultivated to 20cm and offset, with phosphorus applied at sowing.

Six other treatments returned a positive profit over the control after 3 years, and they were all treatments which received no lime, with treatment 4 (no lime, deep cultivated and offset twice with P) having the next highest return with $163. This was followed by treatment 11C ($156) which had no lime applied and was rotary hoed with P and micronutrients applied; treatment 11a ($91) which had no lime or P applied and was rotary hoed; treatment 5 ($59) with no lime and rotary hoed with P; and treatment 2 ($47) no lime, shallow cultivated and offset with P.

Negative profits after 3 years were achieved in treatments where 3t/ha of lime was applied, although less profit was achieved with no cultivation (treatment 6) as opposed to a shallow cultivation (treatment 7).

Treatments receiving the high rate of lime (6t/ha) with P, regardless of cultivation method, generally had increased grain yield and therefore had higher total revenues than treatments without lime, although profits were negative for these treatments due to the upfront cost of lime.

In the nutrient trial adding micronutrients without adding P, regardless of lime application, returned lower revenues, with treatment 11b (no lime or P applied, rotary hoed with micros) having the lowest revenue and one of the lowest profits (-$623). Profits were lowest for the treatments with 6/t lime and no P, treatments 12a (-$680) and 12b (-$604).

Table 2: The profit of each treatment, compared to the control after 3 years (2022-2024)

Trt No.	TREATMENT	*2022 Wheat Grain Yield (kg/ha)*	2022 Revenue *based on wheat $330 on farm	*2023 Canola Grain Yield (kg/ha)*	2023 Revenue *based on canola $625 on farm	*2024 Wheat Grain Yield (kg/ha)*	2024 Revenue *based on wheat $300 on farm	Total Revenue ($)	Treatment Cost ** ($)	Revenue *minus* Treatment Costs ($)	Profit (compared to control)
1	0|nil|P	5643	1862	2467	1542	3639	1092	4495	256	4239	$ 0
2	0|10 cm chisel + offset|P	5660	1868	2538	1586	3852	1156	4609	323	4286	$ 47
3	0|20cm chisel + offset|P	6052	1997	2580	1612	4501	1350	4960	341	4619	$ 380
4	0|20 cm chisel + offest twice|P	5860	1934	2537	1586	4212	1264	4783	381	4402	$ 163
5	0|rotary hoe|P	5251	1733	2612	1632	4196	1259	4624	326	4298	$ 59
6	3|nil|P	5377	1774	2405	1503	3540	1062	4340	593	3747	-$ 492
7	3|10 cm chisel + offset|P	5172	1707	2645	1653	4245	1273	4633	663	3970	-$ 269
8	6|20cm chisel + offset|P	6114	2018	2687	1680	4795	1439	5136	993	4143	-$ 96
9	6|20 cm chisel + offest twice|P	6013	1984	2707	1692	4759	1428	5103	1033	4070	-$ 169
10	6|rotary hoe|P	5931	1957	2745	1716	4268	1280	4953	978	3975	-$ 264
11a	0|rotary hoe|Nil P	5624	1856	2490	1556	3303	991	4403	70	4333	$ 94
11b	0|rotary hoe|Nil P + micro	4310	1422	2280	1425	3275	983	3830	214	3616	-$ 623
11c	0|rotary hoe|P + micro	5834	1925	2661	1663	4254	1276	4865	470	4395	$ 156
12a	6|rotary hoe|Nil P	5285	1744	2525	1578	3198	959	4281	722	3559	-$ 680
12b	6|rotary hoe|Nil P + micro	5538	1827	2529	1581	3643	1093	4501	866	3635	-$ 604
12c	6|rotary hoe|P + micro	6262	2067	2572	1607	4453	1336	5010	1122	3888	-$ 351

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

Cultivation costs 2022

Offset $40/ha

Shallow cultivation $30

Deep cultivation $45

Rotary hoe $70

Other Input costs

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

Micronutrients $28/ha plus $8/ha application

DISCUSSION:

3 seasons after liming, the addition of lime has increased grain yield, compared to no lime. Yields in 2024 were 0.24t/ha higher where lime was applied. Gains were also achieved with cultivation, with cultivation to 20cm by chisel and offset giving better crop performance and higher grain yields than both rotary hoe and cultivation to 10cm. Shallow cultivation to 10cm also produced better grain yields with the addition of lime, as opposed to shallow cultivating without liming.

2024 again showed that the soil was responsive to P fertiliser but not micronutrients, with the addition of micronutrients alone, that is without Phosphorus or lime, resulting in significantly reduced grain yields. Crop vigour, NDVI and grain yield were all higher with the addition of P.

Based on the costs attributed to each treatment only, after 3 years this trial is still showing no economic advantage of lime. Whilst liming is producing greater revenue than no lime, profit is substantially lower than treatments receiving no lime. With a pulse crop planned for 2025, which are generally more sensitive to soil acidity, economic responses to lime are expected to be seen.

The 2-year extension of this project will allow us to complete the rotation, with the paddock to be sown to a pulse crop in 2025. Repeat comprehensive soil tests will be carried out before sowing in 2025 and should provide further data on getting the most out of lime in our soils, including the impact of lime on soil pH and soil P reserves.

This GRDC NGN initiative is led by

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

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