Incorporating Lime to depth on duplex Wheatbelt soils

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AIM

To reduce the impact of acidic soils on plant growth and test the most practical and economical methods of incorporation of lime on duplex soils in the Central Southern Wheatbelt and compare against common top-dressing practice.
The objective is to give growers a greater understanding of different methods of lime incorporation and the most cost-effective practice locally and to extend on other research being conducted on varying soil types throughout the state.

TRIAL DETAILS

Property:	Craig Jespersen – Stretton Farm
Plot size & replication:	12.4m x 12m x 3 Replications
Soil type:	Sandy Loam/Gravel
Crop Variety:	Spartacus Barley
Sowing Date:	20th May 2020
Seeding Rate:	70 kg/ha
Fertiliser:	Vigour 85kgs, UAN 50ltrs, Urea 80kg,
Paddock rotation:	Wheat 2019, Wheat 2018, Lupins 2017, Barley 2016, Wheat 2015
Herbicides:	19/5/2020 – 2.8L/ha trifluralin (IBS) Paraquat 1.6ltrs) 26/6/2020 Jaguar .7L, LVE MCPA .35l, Intervix 375mls, Hasten 1%
Insecticides:	19/5/2020 – 0.1L/ha Alpha Cypermethrin 100EC + 0.1L/ha Chlorpyrifos 500EC
Fungicides:	N/a
pH Treatments	2018 - 0, 2, 4, 6 t/ha Lancelin lime sand + 70kg/ha elemental sulphur
Incorporation Treatments	Topdressed, Deep Ripped, Spaded

METHODOLOGY

The treatments were applied on the 14th March 2018 and were replicated 3 times (Figure 1). The lime was applied at rates of 0, 2, 4 and 6 t/ha and the elemental sulphur was conservatively applied at 1kg/plot or 70kg/ha. The elemental sulphur was applied to increase the acidification of the soil and more rapidly demonstrate the losses that can occur due to acidification. The trial is of broad acre scale with the plot sizes at 12.4m wide x 12m long. This year's trial the site was sown on 20th May 2020 to a Spartacus barley with no further treatments undertaken on those applied in 2018.

Soil sampling was conducted on 15th April 2020 by Precision Soiltech, with 1 sample per plot at increments of 10cm, to a depth of 40cm. Plant germination counts were completed on the 9th July 2020.

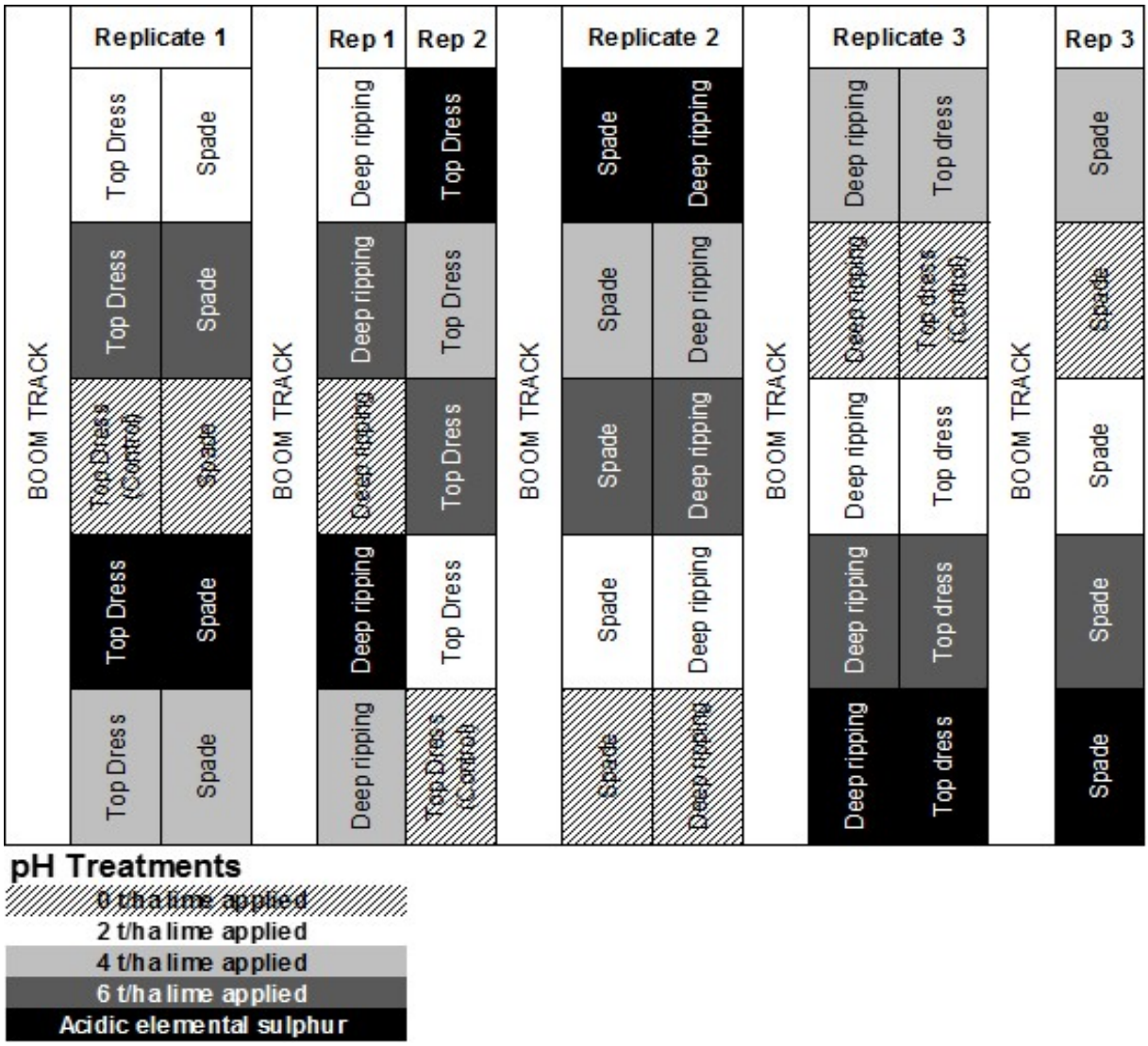

Figure 1: *Trial Layout*

RESULTS & DISCUSSION

Soil Testing

The site was selected from soil cores taken on the 1st March 2018, as well as Dual EM and radiometric precision maps under advisement. The site showed marginal pH levels down the profile with 5.6 in the 0-10cm, 4.9 in 10-20cm and 4.7 in 20-30cm zone in pretrial samples taken in 2018.

Soil tests conducted in 2020 (Figure 2) aimed to show any significant changes in pH between the treatments and incorporation methods introduced in 2018 and through subsequent growing seasons.

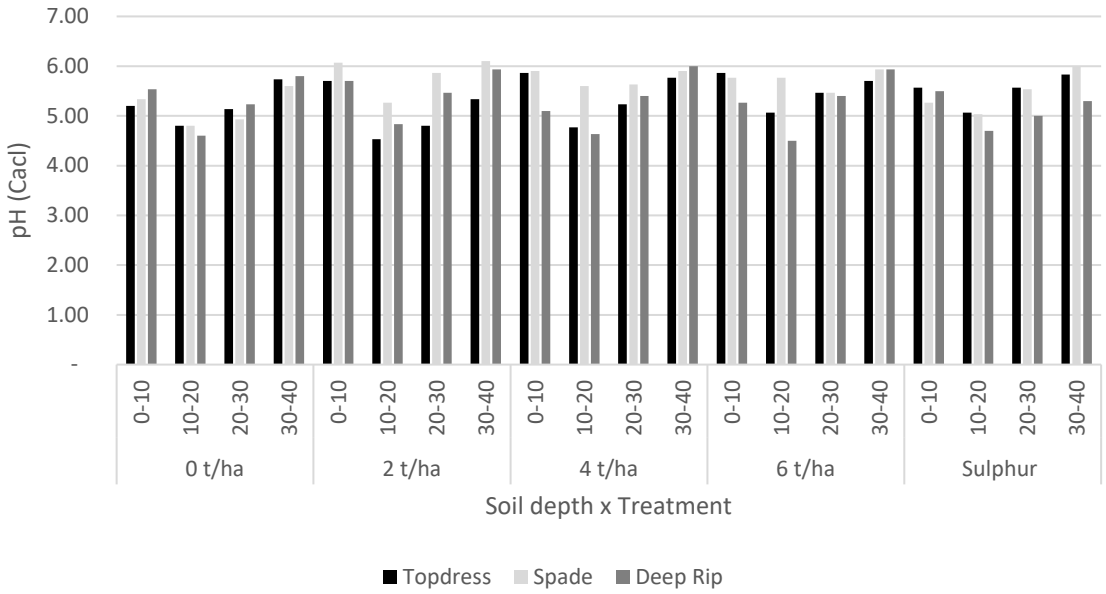

Figure 2: *Soil pH 2020 measured across the soil profile specific to lime application rate and incorporation method*

Multi-Year pH Analysis

Using the results from a multiyear (MET) analysis conducted using the ASReml-R package in R**,** it was observed that the incorporation treatment, Spading, was predicted to perform the best for all pH treatments and for all depths below 0-10cm (*Figure 3*). In terms of the actual results, it was found that, as expected, the highest lime application, (6 t/ha) in combination with spading resulted in the highest increase in pH. Notably though, for the soil depths 20-30cm and 30-40cm all lime application treatments performed nearly equally well, except for the control treatment (0 t/ha lime).

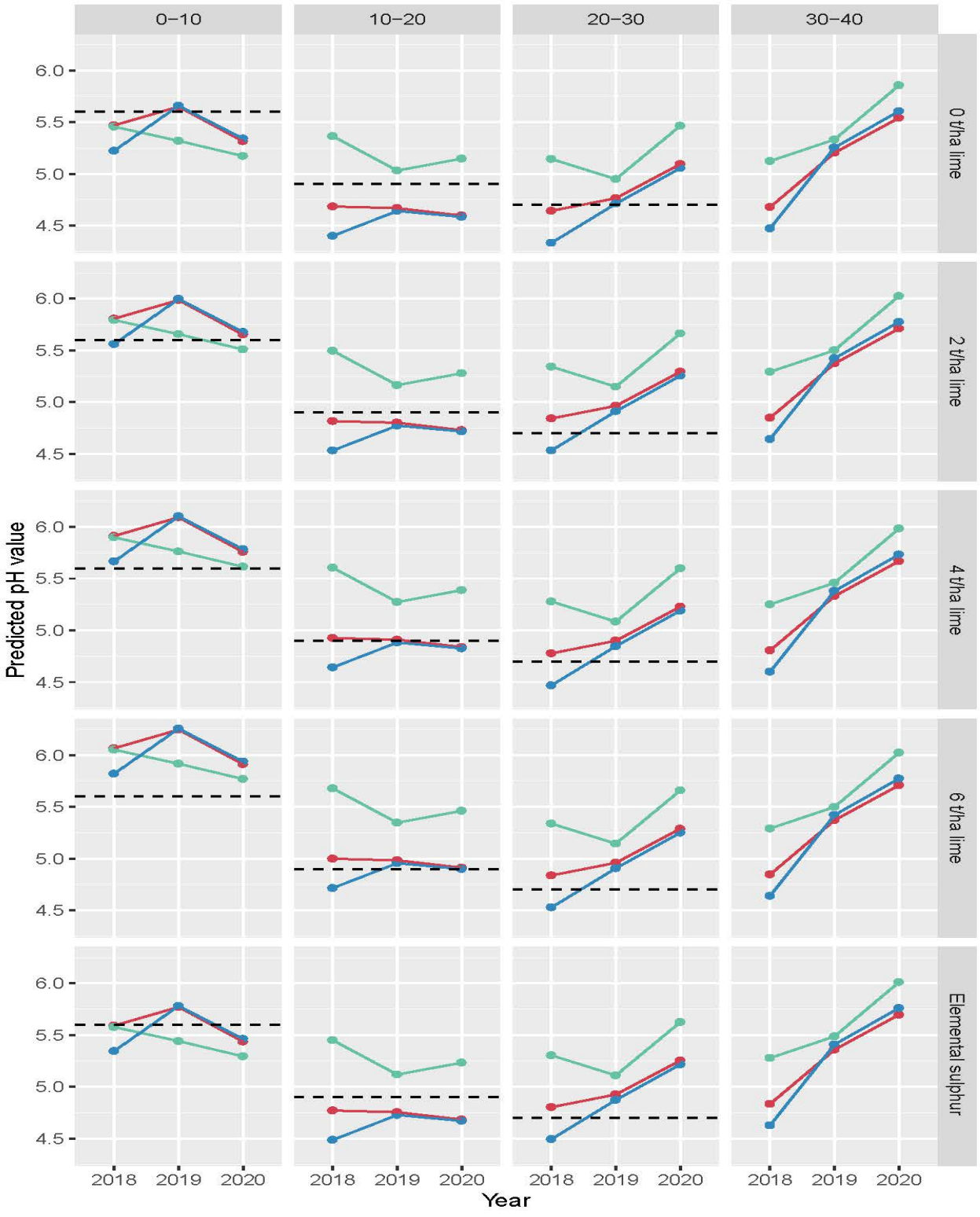

Figure 3 *Predicted pH values over the 2018 to 2020 period using a multiyear MET analysis*

Crop Establishment and Growth (NDVI): Plant establishment counts were not significantly different between treatments (Figure 4). There was an average of 124 plants per/sqm for 0t/ha lime application incorporated by Deep ripping to 170 plants per/sqm for Top dressed lime at 4t/ha (Table 1), which fall mostly within the recommended densities for food barley of 120 – 150 plants per/sqm.

***Table 1**: Average plants per/sqm by lime application rate x incorporation method*

	0 t/ha	2 t/ha	4 t/ha	6 t/ha	Sulphur
Incorporation - Top Dress	155	158	170	152	139
Incorporation - Deep Rip	124	155	129	156	128
Incorporation - Spading	136	141	132	132	131

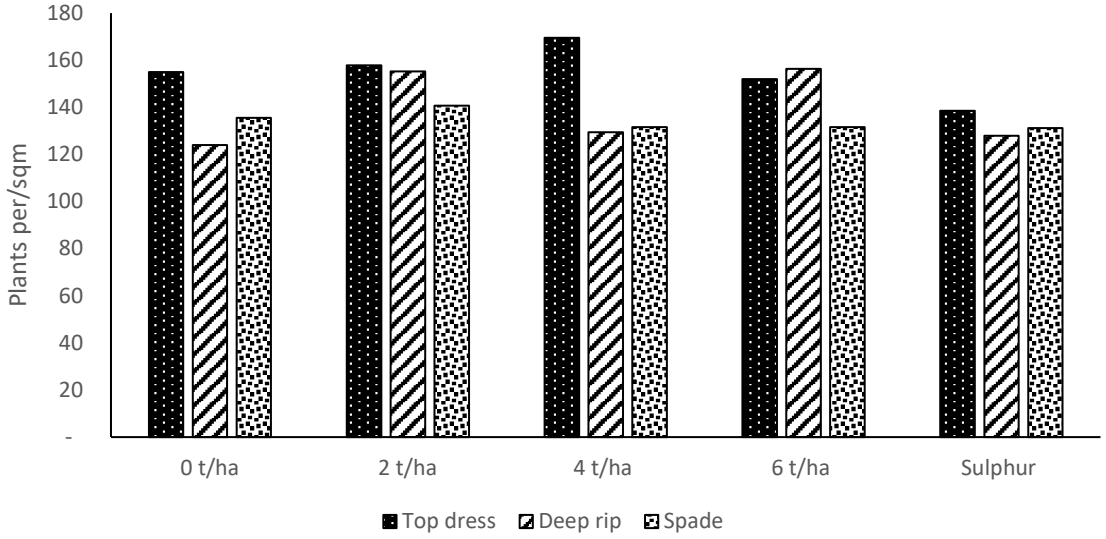

***Figure 4** Average plants per/sqm by lime application rate and incorporation methods*

Crop growth measured as NDVI in Figure 5 indicates that Deep ripped lime application at all rates including a nil appliation produced slighty higher growth scores. Top Dress and Spaded lime incorporation NDVI scores were not significanlty different at growth stage Z14.

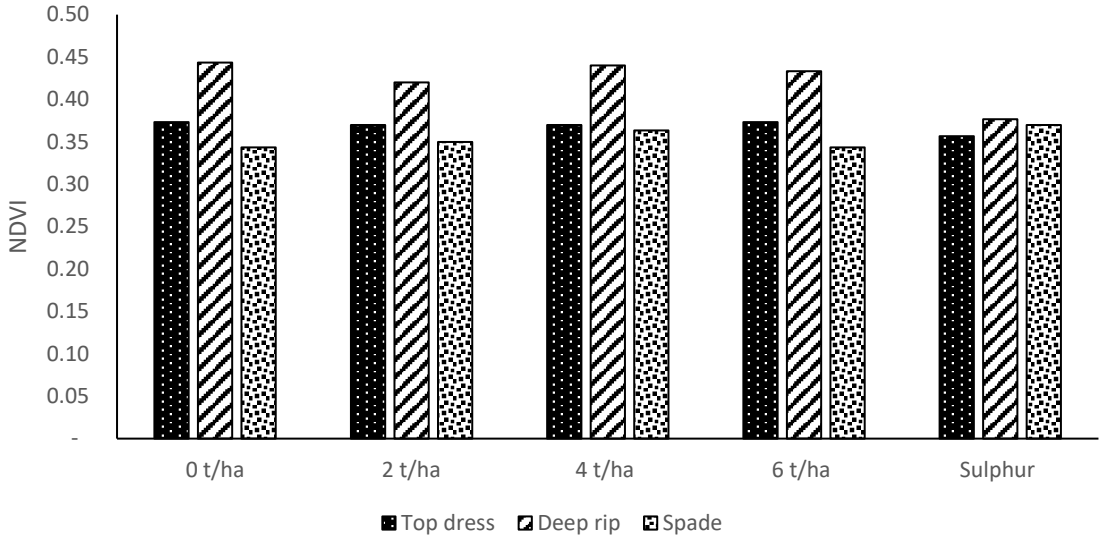

***Figure 5** Average plant establishment measured as NDVI at Z14, across different lime application rates and incorporation methods*

Harvest Yield

Harvest yield data was collected using a small plot header (figure 6).

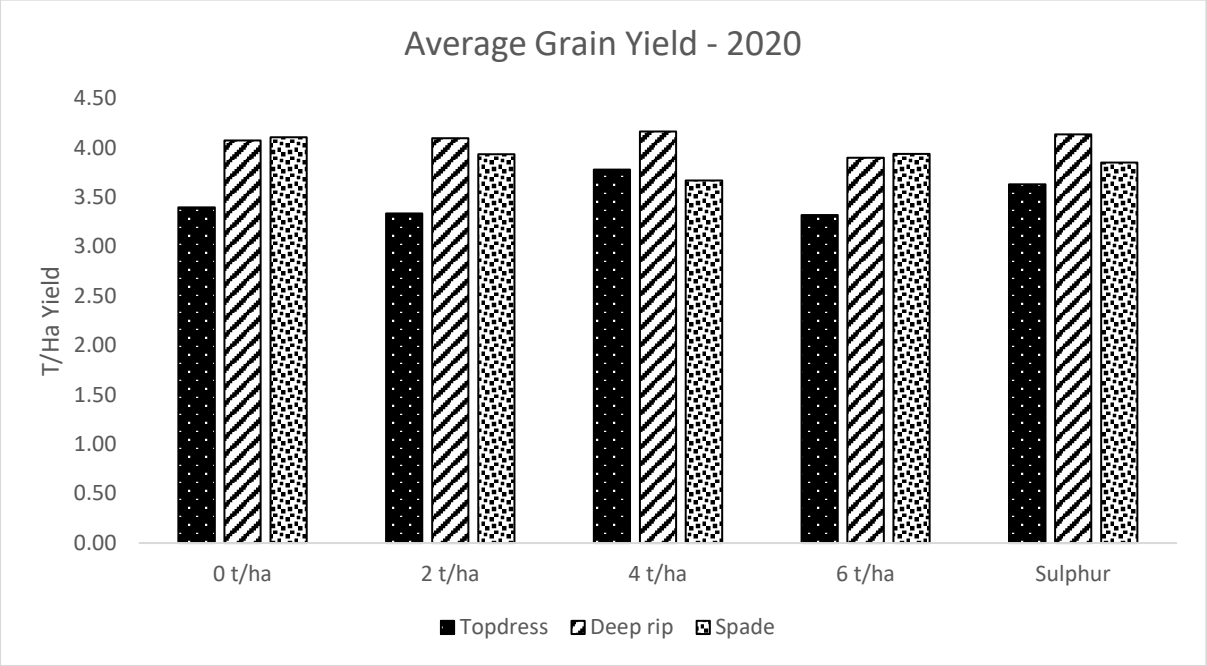

Figure 6: *Harvest Yield Data for each lime application rate and incorporation method - 2020*

The yield data for each treatment was analysed to determine any significant interactions. The effect of incorporation method on grain yield was found to be highly significant ($p<0.001$). Lime application rate, and the interaction between lime rate and incorporation method was not found to be significant. The Deep rip treatment had the greatest impact on grain yield, followed closely by the Spade treatment.

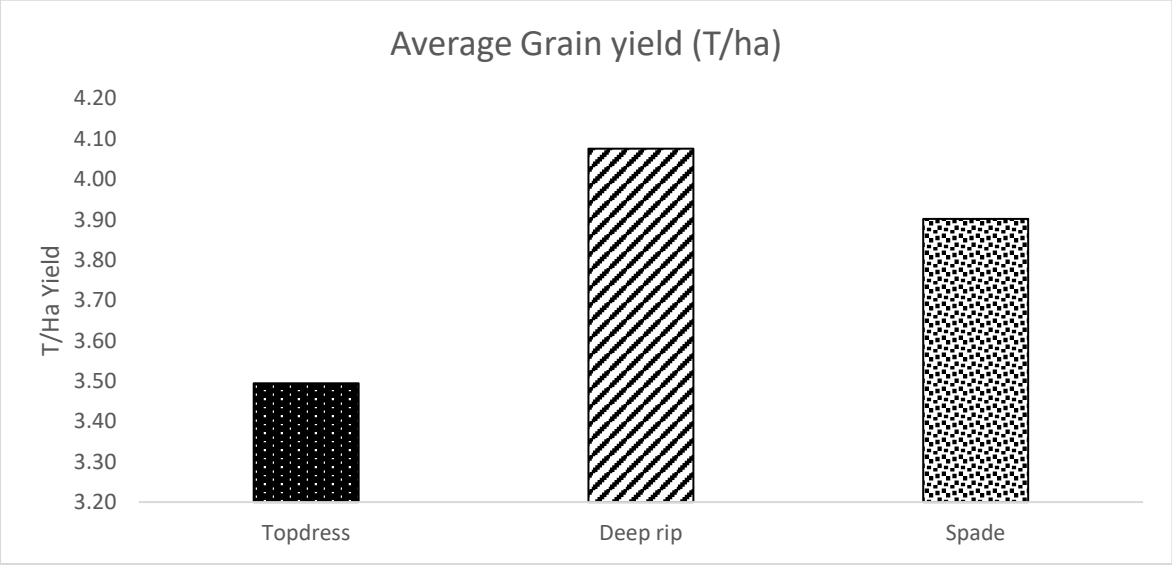

Figure 7: *Average grain yield for each incorporation method - 2020*

The average grain yield for each incorporation method is highlighted in Figure 7. Deep ripping had the highest average yield at 4.08t/ha, where as topdressing resulted in the lowest average yield of 3.49t/ha. These results indicate an incorporation method boosts grain yield when compared to common practice of top dressing lime only.

Grain Quality

Grain protein and quality was assessed for each of the three replicates of each treatment, with the averages represented in Figure 8 and Table 2. Incorporation method and pH treatment did not significantly impact on grain protein, hectolitre weight or screenings. All treatments except Top Dress with Sulphur application met the protein requirements of malt1 (9.5-12.8%). The highest average protein occurred in the Spade with 4 t/ha lime treatment (10.8%), and this was also the treatment with the highest average screening percentage (60.27%).

The third replicate of each treatment consistently reported the highest protein level of each replicate, except for the Top Dress Sulphur treatment (9.7, 9.1, 9.4%). The screening percentage of the third replicate of each treatment was also consistently higher than replicates one and two. The third replicate of the Spade treatments reported the highest screening values overall, ranging from 53.66-91.81%. An environmental influence, for example frost which can shrink grain size and increase protein could potentially have impacted on the protein and screenings of the third replicate of the trial, resulting in high protein and screenings variability between replicates of each treatment. The standard deviations presented in Table 2 represent which treatments had high variation between replicates.

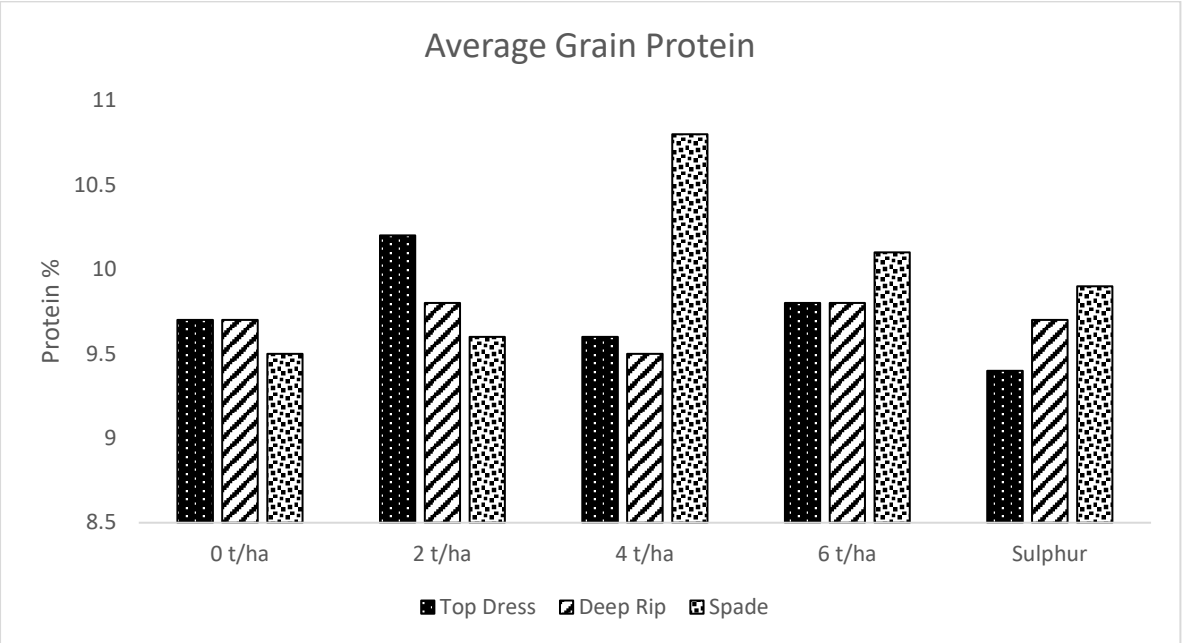

Figure 8: *Average grain protein for each incorporation method and pH treatment.*

Table 2: Average hectolitre weight and screenings for each treatment

pH treatment	Incorporation method	Hectolitre (g)	SD	Hectolitre (%)	SD	Screenings (%)	SD
0 t/ha	Top Dress	335.73	3.81	67.15	0.76	27.86	7.65
	Deep Rip	335.6	4.69	67.12	0.94	35.35	11.27
	Spade	341.27	1.55	68.25	0.31	34.32	13.72
2 t/ha	Top Dress	333.03	2.25	66.61	0.45	33.07	13.92
	Deep Rip	339.03	2.26	67.81	0.45	35.24	14.58
	Spade	342.27	6.82	68.45	1.36	41.59	30.17
4 t/ha	Top Dress	339.07	1.72	67.81	0.34	22.81	5.16
	Deep Rip	343.77	2.25	68.79	0.45	31.73	9.68
	Spade	334.83	2.10	66.97	0.42	60.27	22.33
6 t/ha	Top Dress	333.5	9.31	66.7	1.86	23.62	4.10
	Deep Rip	336.2	12.38	67.24	2.48	34.54	22.93
	Spade	342.13	6.47	68.43	1.29	47.95	27.16
Sulphur	Top Dress	331.99	6.93	66.4	1.39	22.24	4.77
	Deep Rip	303.63	56.89	67.99	1.13	38.41	15.03
	Spade	341.1	8.93	68.22	1.79	50.52	25.27

CONCLUSION

This trial has been run over three different growing seasons and the soil amelioration methods have had time to consolidate there have been notable changes in the pH levels under different lime application rates and incorporation methods.

The results from the statistical data analysis conducted by SAGI West using a single year model showed that the effect of the pH treatment should weaken with time, with its affect on the soil pH only being significant in 2018. It also showed that there was no interaction between the pH treatment and the soil incorporation method.

The results of this analysis have been combined over multiple years of the trial using a MET analysis. This analysis showed that the best soil incorporation technique for increasing the soil pH was spading, which was true for all depths below 0-10cm. Although the highest application of lime (6t/ha) had the best results, at depths between 20-30cm and 30-40 cm, all treatments performed equally well, except for the control treatment (0 t/ha). From 2018 to 2020 an upward trend (increasing soil pH) was observed at the depths 20-30cm and 30-40cm, for all soil incorporation and pH treatments. However, the effect on a year by year basis for the top and subsoil (0-10cm and 10-20cm) from the soil incorporation and pH treatments did not show a definable trend, with the pH in 2020 being slightly lower or higher than the pH in 2018.

The results of the 2020 trial indicate that grain yield can be influenced by incorporation method. Lime application rate did not impact on grain yield however. Therefore, to increase grain yield producers should factor incorporation method into management decisions to boost productivity. Lime application rate was impactful on pH in the year of application, but did not correlate into an increased grain yield for subsequent crops. The pH levels of the soil may not have been acidic enough to impact on grain yield in this trial, hence the lack of response to lime application rate in grain yield.

ACKNOWLEDGEMENTS

The GRDC for investing in and supporting this project; SAGI WEST for providing the statistical data analysis and reporting and Craig Jespersen for hosting, installing and maintaining the trial site.