CarbonAg

FIELD RESEARCH PROGRAM REPORT 2021

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Executive summary

Carbon Ag conducted four agronomic field trials in different locations across Western Australia in 2021. The season was very favourable to crop growth, with good rainfall and limited frost. This resulted in a record harvest for the State, which also was reflected in these trial results, and it coincided with relatively high grain prices.

The Carbon Ag liquid fertiliser program centres on the frequent and balanced provision of nutrients. A novel potassium phosphate fertiliser applied at seeding and as foliar sprays allows post-emergent application of P and K alongside N during a good rainfall year. This maximised yields in three out of the four small plot agronomic trials compared with standard practice of the corresponding district. At Latham (wheat), the Carbon Ag program delivered on average 700 kg/ha more yield than the local practice. This resulted in net profits of up to $1,500/ha. At Quairading (wheat), yields were up to 239 kg/ha higher with the Carbon Ag liquids program, resulting in $433/ha more farm income. At Wittenoom Hills, the Carbon Ag Program performed as well as the district practice, with very comparable yields and net gains. For the final site (Northam, canola) the Carbon Ag liquid program achieved 758 kg/ha or 34% more yield than the standard practice, resulting in net profits of up to $4,700/ha.

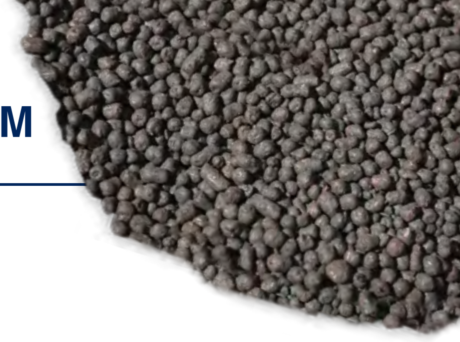
In addition to boosting farm income, the Carbon Ag program also incorporates the C33 amendment pellet as a tool to increase soil carbon and health in the long-term. This product, combined with the increased plant productivity under the Carbon Ag program, meant that post-harvest soil carbon values were often higher in the Carbon Ag treatments than under district practice.

At Latham, up to 188 kg/ha more carbon was present in the top 10 cm of soil under the Carbon Ag liquid program and C33 amendment. For Quairading, this was even higher, with up to 598 kg/ha more carbon, followed by Northam with 637 kg/ha additional carbon. Higher soil carbon concentrations are directly linked to higher soil nutrition, soil water retention and microbial activity. These are indirect benefits that are difficult to quantify, yet play a vital role in plant health and productivity. In these trials, post-harvest soil nutrition frequently showed elevated concentrations of soil nitrate, phosphate and potassium concentrations in the top 10 cm of soil. These improvements in soil nutrition will benefit next year's crop. Additionally, three of the four trials showed trends for increased soil pH in the top 10 cm following organic matter application, without any negative effects on soil EC.

Combined, the results of both yield increases and soil health improvements in the first year of trials at each of these locations are very encouraging. The liquid potassium phosphate fertiliser allows flexibility to dynamically respond to the developing season, thereby reducing business risk of foregoing inputs. Simultaneously, increased plant productivity and the C33 amendment boosts soil health, which is a long-term investment for any sustainable farming enterprise.

Trials in future years will focus on fine-tuning the Carbon Ag program on a variety of soil types and under different rainfall scenarios. The aim is to maximise farm profitability without jeopardising long-term soil health.

In addition to boosting farm income, the Carbon Ag program also incorporates the C33 amendment pellet as a tool to increase soil carbon and health in the long-term.



INTERACTIVE CONTENTS

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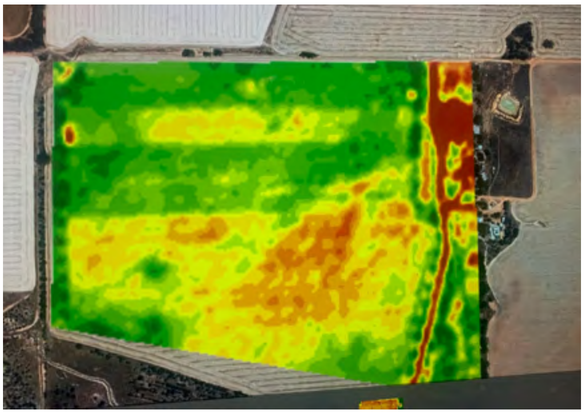
Introduction

Carbon Ag was established in 2017 with the aim to provide a range of carbon products to the Western Austrian broadacre agricultural sector. A variety of products are now available, including loose compost and the flagship product, C33. These products aim to improve soil health, build soil carbon, and hence increase soil fertility in the long-term.

Since its inception, Carbon Ag has expanded its product portfolio, offering a variety of liquid fertilisers. These are designed to help farmers deliver balanced nutrition and increase crop yields. Most importantly, a novel liquid potassium phosphate fertiliser has been developed and trialled to allow foliar top-up of this vital plant nutrient. This product, in combination with the common post-emergent foliar application of nitrogen, allows growers to dynamically respond to the season. In a favourable season, more NPK can now be delivered via one, two or three foliar sprays, maximising yield. Conversely, during a dry start to the season, less P can be applied at seeding, with the option to apply more should the outlook improve. This reduces business risk as start-up fertiliser presents an investment that cannot necessarily be recovered if rainfall is lacking.



Carbon Ag prides itself on its commitment to ongoing R & D. In 2021, small plot, agronomic field trials were conducted to rigorously assess product performance and effects on soil health. These are complemented by ambassador demonstrations conducted at the paddock scale. Here, soil heterogeneity strongly influences crop growth and productivity. In response to the additional challenge, Carbon Ag has invested in mapping tools such as the VERIS system (soil carbon, pH and EC), EM surveys and NDVI biomass imagery from drone and satellite. Acknowledging and working within the complexities of the agricultural production system drives Carbon Ag to innovate and provide better services and products to its clients.

This report contains the Carbon Ag 2021 trial data. Four agronomic field trials were conducted in different locations across Western Australia. A number of paddock scale trials also were completed as part of the Carbon Ag ambassador program. The 2021 season was very favourable to crop growth, with good rainfall and limited frost. This resulted in a record harvest for the State. GIWA reported close to 12 million tonnes of harvested wheat in its December 2021 crop report. These outstanding yields are reflected in the following trial results.

LATHAM TRIAL REPORT (WHEAT)

Aim

The aim of this wheat trial was to assess the effects of the Carbon Ag liquid fertiliser program with and without the addition of C33 carbon pellets on wheat growth and yields.

Trial location: Dylan Hirsch, Latham, Western Australia

Soil type: Yellow sand

Paddock history: 2020: lupins

Crop & sowing Date: Wheat 70 kg/ha sown on the 14th of May 2021

Trial design and fertiliser applications

Seeding treatments

Treatment No.	Treatment name	Seed treatment	UAN (L/ha)	MAP (kg/ha)	MOP (kg/ha)	Power PK (L/ha)	C33 Pellets (kg/ha)	Bioactive (L/ha)
1	UFC	None	0	0	0	0	0	0
2	GSP	None	70	45	35	0	0	0
3	LP	BSN10	77	25	12	15	0	5
4	LP + C33 low	BSN10	77	25	12	15	30	5
5	LP + C33 med	BSN10	77	25	12	15	40	5
6	LP + C33 high	BSN10	77	25	12	15	50	5

UFC = unfertilised control; GSP = grower standard practice; LP = Carbon Ag liquid program.

Foliar treatments

Treatment No.	Treatment name	*1st Foliar spray – 22/06/2021*				*2nd Foliar spray – 22/07/2021*			
		UAN (L/ha)	Power PK (L/ha)	Cereal Plus Max (L/ha)	Bioactive (L/ha)	UAN (L/ha)	Power PK (L/ha)	Cereal Plus Max (L/ha)	Bioactive (L/ha)
1	UFC	0	0	0	0	0	0	0	0
2	GSP	55	0	0	0	0	0	0	0
3	LP	30	3	4	5	100	2	2	2
4	LP + C33 low	30	3	4	5	100	2	2	2
5	LP + C33 med	30	3	4	5	100	2	2	2
6	LP + C33 high	30	3	4	5	100	2	2	2

UFC = unfertilised control; GSP = grower standard practice; LP = Carbon Ag liquid program.

Total nutrients applied

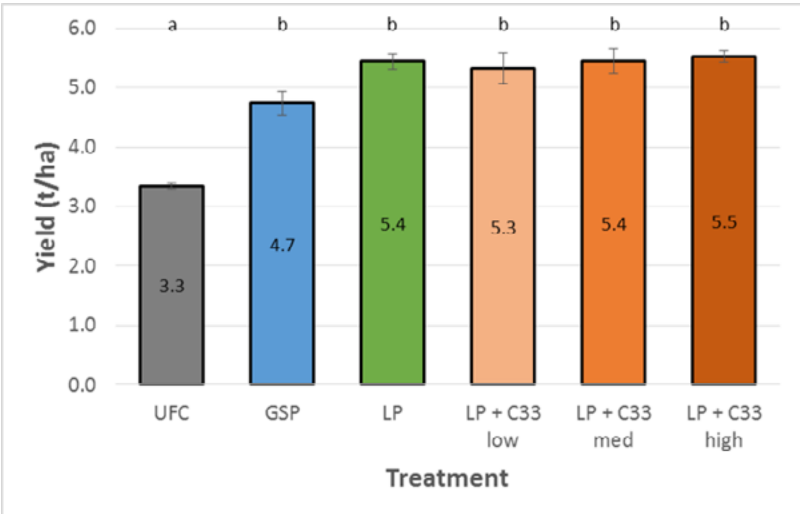
Treatment No.	Treatment name	N	P	K
1	UFC	0	0	0
2	GSP	42	10	17
3	LP	65	11	16
4	LP + C33 low	65	11	17
5	LP + C33 med	66	11	17
6	LP + C33 high	66	11	17

UFC = unfertilised control; GSP = grower standard practice; LP = Carbon Ag liquid practice.

Growing season rainfall: 293.8 mm

Yield

The unfertilised control delivered significantly lower yields than all other treatments (P ≤ 0.02, LSD = 1.40 t/ha). The Carbon Ag liquid program, with or without carbon pellets, increased yields compared with grower practice by on average 15% or 0.7 t/ha.



ROI

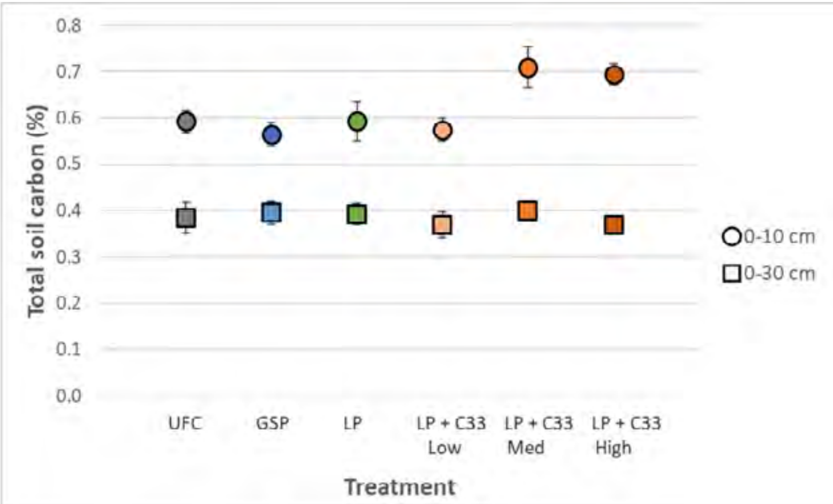
The Carbon Ag liquid program achieved higher net gains (on average $253/ha) and ROI than the grower standard practice.

Treatment No.	Treatment name	Fertiliser input ($/ha)	Harvest income ($/ha)	Net gain ($/ha)	ROI (%)
1	UFC	$0	$1,270	$1,270	n/a‡
2	GSP	$551	$1,800	$1,249	227%
3	LP	$562	$2,068	$1,506	268%
4	LP + C33 low*	$562	$2,021	$1,459	260%
5	LP + C33 med*	$562	$2,068	$1,506	268%
6	LP + C33 high*	$562	$2,098	$1,536	273%

**Note: The cost of C33 was not included in these calculations as C33 is designed to build soil carbon, which is a long-term investment in soil health. ‡ ROI for the unfertilised control cannot be calculated due to division by zero. Transport costs and other crop protection products were excluded in the net gain and ROI calculations. Calculations are based on a wheat price of $380/t.*

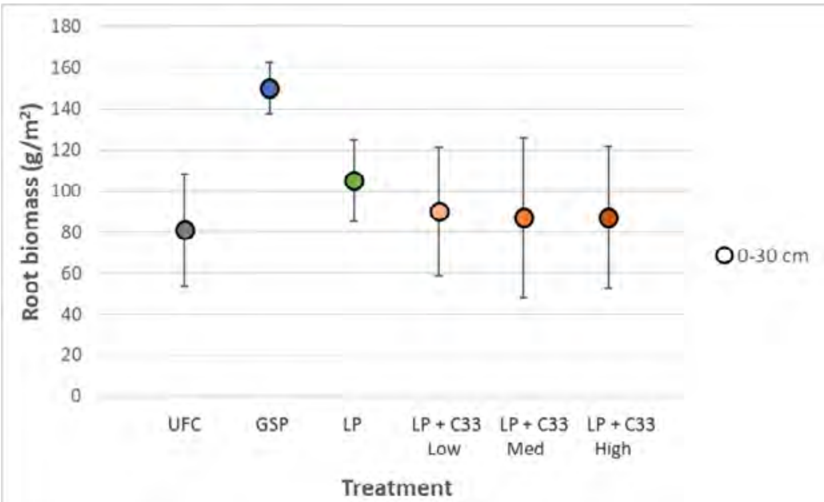
Total soil carbon (post-harvest)

Compared with grower standard practice, soil carbon concentrations in the top 10 cm increased by 0.14% and 0.13% in treatments where 40 kg/ha and 50 kg/ha respectively of C33 carbon pellets were applied. The increases in soil carbon percentages translate to up to 188 kg/ha of more total soil carbon in this layer. When looking at the top 30 cm of soil, the increases in soil carbon near the surface do not translate to an overall carbon increase over this depth interval.



Root biomass (post-harvest)

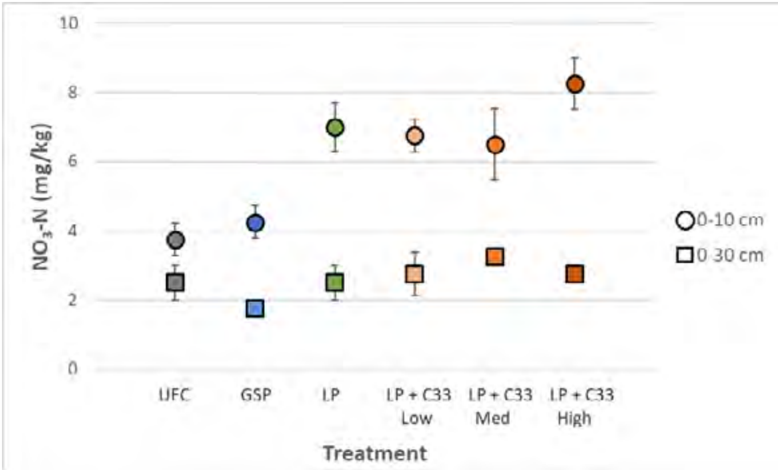
Root biomass was determined after harvest for the top 30 cm of soil. Grower standard practice showed the highest root biomass compared with other treatments, however this was not statistically significant (one-way ANOVA P = 0.253).



Soil fertility (post-harvest)

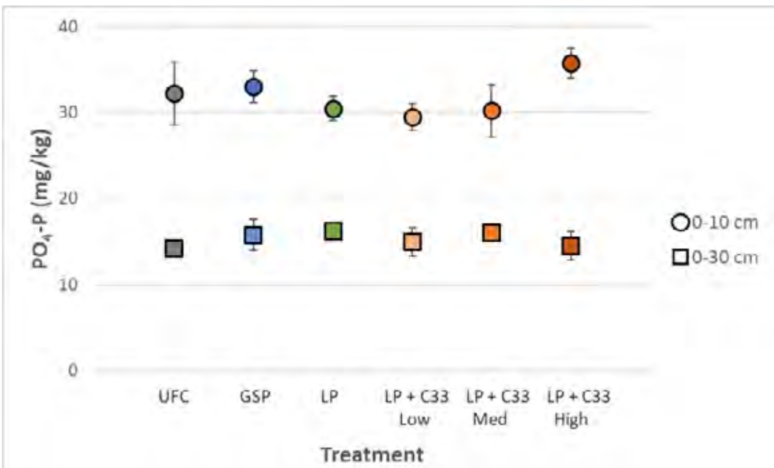
Nitrate-N

Concentrations of nitrate-N in the top 10 cm of soil were higher under the Carbon Ag liquid program compared with the unfertilised control and the grower standard practice. This increase was significant for LP + C33 low and LP + C33 high compared with the untreated control ($P \leq 0.031$), and for LP + C33 high compared with grower standard practice ($P = 0.039$). This increase is likely due to the additional nitrogen inputs in these treatments in both inorganic and organic forms (UAN and Bioactive respectively). In 0-30 cm soil cores, no increases in nitrate concentrations occurred. This is of significance, as it suggests that surface-applied nitrate does not leach into deeper soil layers and below the root zone, ie, is not lost and does not contribute to pollution.



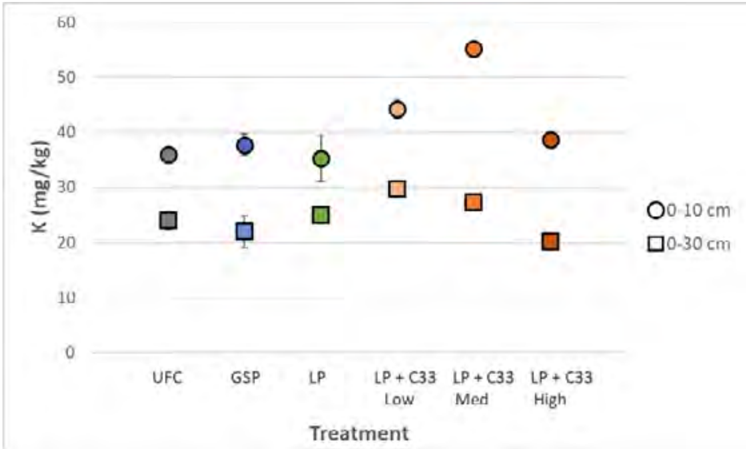
Phosphate-P

There were no significant differences in soil P concentrations in the top 10 cm despite a small increase on the LP + C33 high treatment (one-way ANOVA $P = 0.340$). This suggests that P applied as liquid both at seeding and as foliar sprays was taken up by plants as efficiently as granular P in the grower standard practice. Similar to nitrate, phosphate concentrations across the top 30 cm soil column were unaltered by farming practices. This is a positive outcome, as seemingly no leaching of phosphate occurred and the nutrient remains available for next year's crop.



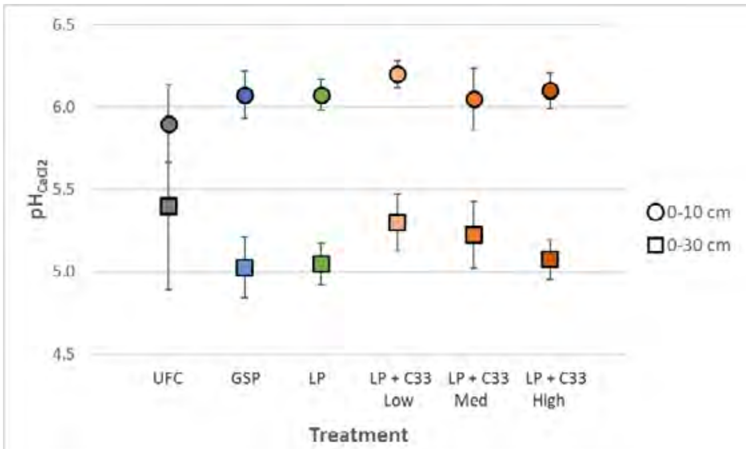
Potassium

Potassium concentrations in the top 10 cm of soil were elevated under the Carbon Ag liquid program when the C33 pellet was added compared with the grower standard practice. For treatment LP + C33 Med, this was significant ($P < 0.001$). No significant differences in potassium levels were detected between the Carbon Ag liquid program and the grower standard practice across the 0-30 cm soil horizon.



Soil pH

Soil pH_{CaCl2} in the top 10 cm did not differ significantly between farming practices. The same was true for the top 30 cm.



Conclusions

A good rainfall year and a dynamic response to the season enabled by the Carbon Ag liquid fertiliser program delivered on average 700 kg/ha more grain compared with the grower standard practice of the district. This translated to an increase in net profit of $253/ha on average. The Carbon Ag liquid program, combined with the C33 pellets, helped increase soil carbon levels by up to 188 kg/ha in the first year of trials at this site. More soil carbon means better soil water retention, potential carbon sequestration and general increased soil health. These are encouraging results that can be built upon by continuing the trial in the same location over future years.

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Appendix

Soil fertility (post-harvest)

Treatment No.	Treatment name	Depth (cm)	pH_{H2O}	pH_{CaCl2}	EC (dS/m)	NO_3-N (mg/kg)	PO_4-P (mg/kg)	K (mg/kg)	S (mg/kg)	C (%)
1	UFC	0-10	6.90	5.90	0.04	3.75	32.3	36.0	3.25	0.59
2	GSP	0-10	6.95	6.08	0.04	4.25	33.0	37.8	3.25	0.57
3	LP	0-10	6.95	6.08	0.04	7.00	30.5	35.3	2.80	0.59
4	LP + C33 low	0-10	7.05	6.20	0.05	6.75	29.5	44.3	3.60	0.58
5	LP + C33 med	0-10	6.98	6.05	0.04	6.50	30.3	55.3	3.35	0.71
6	LP + C33 high	0-10	6.95	6.10	0.05	8.25	35.8	38.8	3.25	0.70
1	UFC	0-30	6.30	5.40	0.04	2.50	14.3	24.0	15.7	0.39
2	GSP	0-30	5.95	5.03	0.04	1.75	15.8	22.0	14.2	0.40
3	LP	0-30	5.95	5.05	0.04	2.50	16.3	25.0	16.2	0.39
4	LP + C33 low	0-30	6.10	5.30	0.04	2.75	15.0	29.8	14.0	0.37
5	LP + C33 med	0-30	6.05	5.23	0.04	3.25	16.0	27.3	14.1	0.40
6	LP + C33 high	0-30	5.90	5.08	0.04	2.75	14.5	20.3	14.5	0.37

QUAIRADING TRIAL REPORT (WHEAT)

Aim

The aim of this wheat trial was to assess the effects of the Carbon Ag liquid fertiliser program with and without the addition of C33 carbon pellets on wheat growth and yields.

Trial location: Linden Johnston, Quairading, Western Australia

Soil type: Loamy sand

Paddock history: 2020: pasture

Crop & sowing Date: Wheat 70 kg/ha (cv. Vixen) sown on the 27th of May 2021

Trial design and fertiliser applications

Seeding treatments

Treatment No.	Treatment name	Seed treatment	UAN (L/ha)	MAP (kg/ha)	MOP (kg/ha)	Power PK (L/ha)	C33 Pellets (kg/ha)	Bioactive (L/ha)
1	UFC	None	0	0	0	0	0	0
2	GSP	None	70	45	35	0	0	0
3	LP	BSN10	77	25	12	15	0	5
4	LP + C33 low	BSN10	77	25	12	15	30	5
5	LP + C33 med	BSN10	77	25	12	15	50	5
6	LP + C33 high	BSN10	77	25	12	15	70	5

UFC = unfertilised control; GSP = grower standard practice; LP = Carbon Ag liquid practice.

Foliar treatments

Treatment No.	Treatment name	*1st Foliar spray – 13/07/2021*				*2nd Foliar spray – 22/07/2021*			
		UAN (L/ha)	Power PK (L/ha)	Cereal Plus Max (L/ha)	Bioactive (L/ha)	UAN (L/ha)	Power PK (L/ha)	Cereal Plus Max (L/ha)	Bioactive (L/ha)
1	UFC	0	0	0	0	0	0	0	0
2	GSP	100	0	0	0	0	0	0	0
3	LP	100	5	3	4	100	2	2	2
4	LP + C33 low	100	5	3	4	100	2	2	2
5	LP + C33 med	100	5	3	4	100	2	2	2
6	LP + C33 high	100	5	3	4	100	2	2	2

UFC = unfertilised control; GSP = grower standard practice; LP = Carbon Ag liquid program.

Total nutrients applied

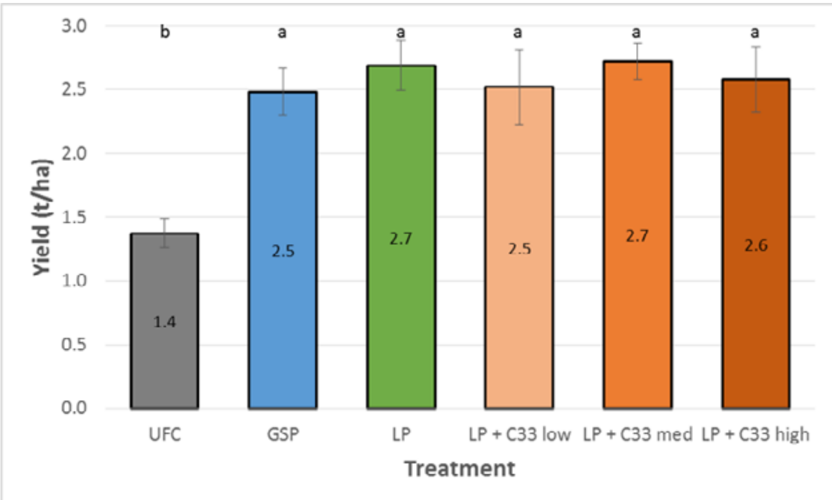
Treatment No.	Treatment name	N	P	K
1	UFC	0	0	0
2	GSP	77	10	17
3	LP	121	11	17
4	LP + C33 low	121	11	18
5	LP + C33 med	122	11	18
6	LP + C33 high	122	11	18

UFC = unfertilised control; GSP = grower standard practice; LP = Carbon Ag liquid practice.

Growing season rainfall: 227.8 mm

Yield

There was a significant yield increase in all fertilised treatments compared with the unfertilised control (one-way ANOVA P = 0.002). Compared with the grower standard practice, the Carbon Ag liquid program delivered some additional increases in yield.



ROI

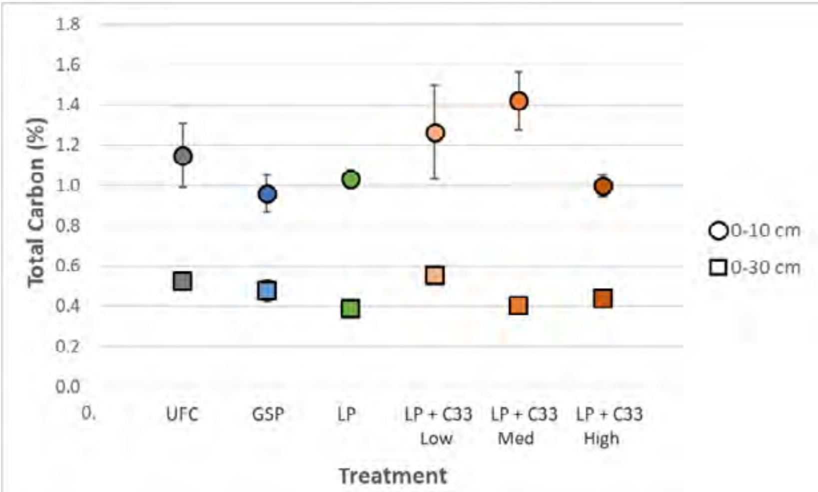
The Carbon Ag liquid program achieved slightly higher net gains (on average $50/ha) and ROI in three out of four treatments compared with the grower standard practice.

Treatment No.	Treatment name	Fertiliser input ($/ha)	Harvest income ($/ha)	Net gain ($/ha)	ROI (%)
1	UFC	$0	$523	$523	n/a‡
2	GSP	$583	$943	$361	62%
3	LP	$601	$1,022	$421	70%
4	LP + C33 low*	$601	$958	$357	59%
5	LP + C33 med*	$601	$1,034	$433	72%
6	LP + C33 high*	$601	$979	$378	63%

**Note, the cost of C33 was not included in these calculations as C33 is designed to build soil carbon, which is a long-term investment in soil health. ‡ ROI for the unfertilised control cannot be calculated due to division by zero. Transport costs and other crop protection products were excluded in the net gain and ROI calculations. Calculations are based on a wheat price of $380/t.*

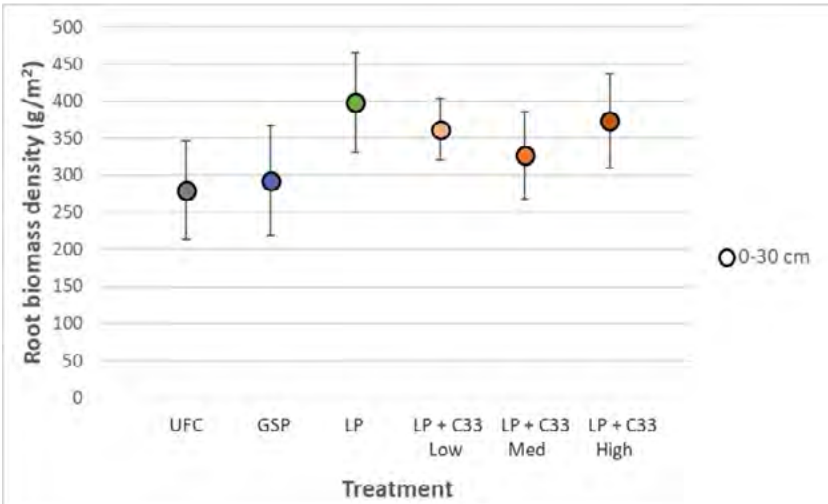
Total soil carbon (post-harvest)

Total soil carbon was markedly increased in two of the Carbon Ag liquid program treatments compared with the grower standard practice in the top 10 cm of soil. Both LP + C33 Low and LP + C33 Med showed 0.31% and 0.46% additional carbon in this soil layer. This equates to 397 kg/ha and 598 kg/ha respectively of additional soil carbon.



Root biomass (post-harvest)

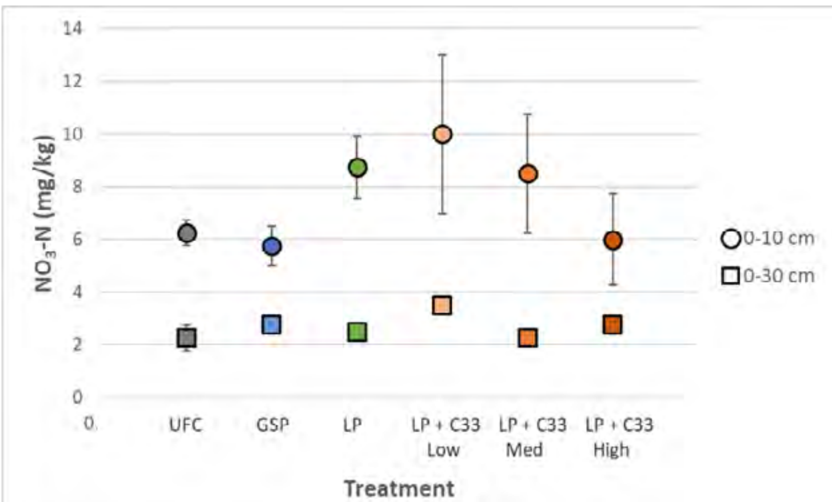
There was a trend for increased root biomass for all treatments involving the Carbon Ag liquid program compared with unfertilised control and grower standard practice. On average, the crop showed comparatively high root biomass with the Carbon Ag program.



Soil fertility (post-harvest)

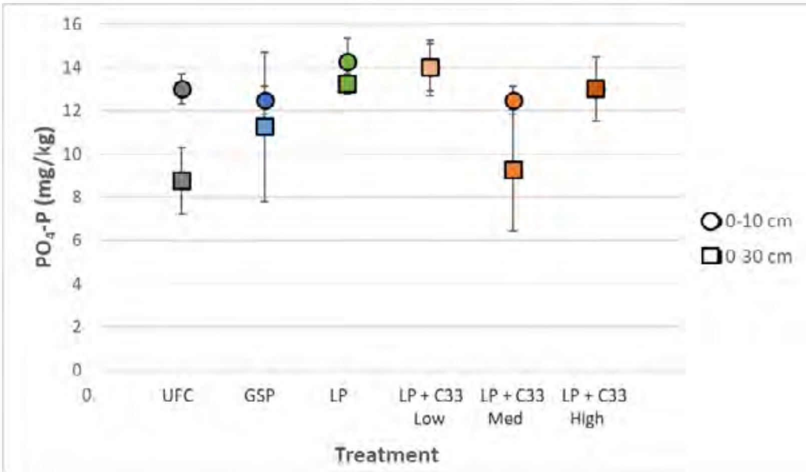
Nitrate-N

The Carbon Ag liquid program resulted in on average 2.6 mg/kg or 45% more nitrate in the top 10 cm of soil than the grower standard practice. This effect was less pronounced when assessing the top 30 cm of soil, where generally lower concentrations of nitrate occurred.



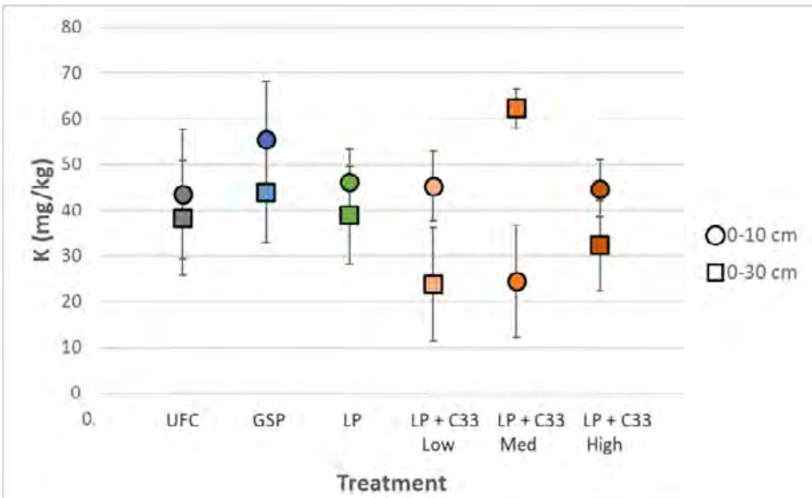
Phosphate-P

In the top 10 cm of soil, there was on average 0.94 mg/kg or 7.5% more P in the soil under the Carbon Ag liquid program than the grower standard practice. For the top 30 cm, three of the four Carbon Ag liquid treatments resulted in 1.75 to 2.75 mg/k more P than the grower standard practice.



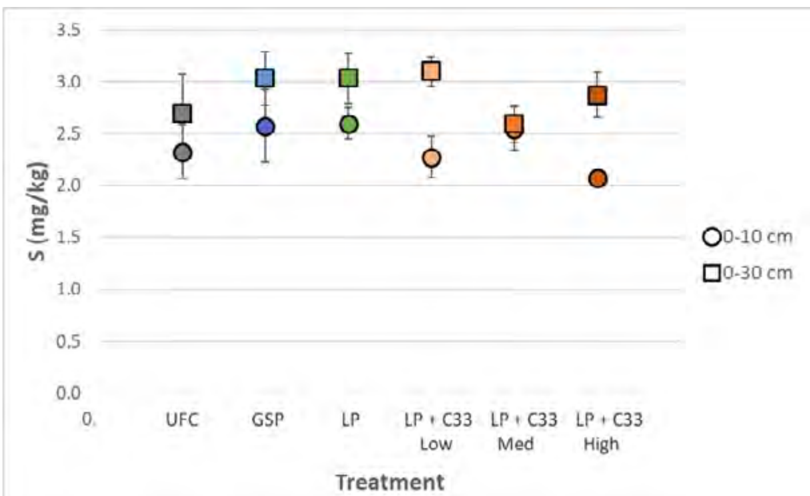
Potassium

Potassium concentrations were very variable across both soil horizons, as indicated by large standard error bars. Treatment 5 (Carbon Ag LP + C33 Med) stood out for having the highest concentration of K in the top 10 cm of soil. Interestingly, treatments 4 and 5 exhibited the lowest K concentrations across the top 30 cm of soil. However, this seemingly had no influence on yield.



Sulphur

Sulphur was the only measured element that stood out as potentially yield-limiting at this site. DPIRD *(please refer to link)* gives <5 mg/kg in the top 10 cm of soil as likely deficient. However, this can be abated by sulphur at depth. At this site, the sulphur concentrations were below 4 mg/kg, in both soil horizons assessed (ie, top 10 cm and top 30 cm), suggesting deficiency of this nutrient could have resulted in relatively low yields at this site during an otherwise favourable season. Some S was supplied in the seeding fertiliser (MAP contains 1.2% S) and as foliar spray (Cereal Plus Max contains 3%). However, DPIRD states that foliar sprays cannot sufficiently supply enough sulphur for plant needs.



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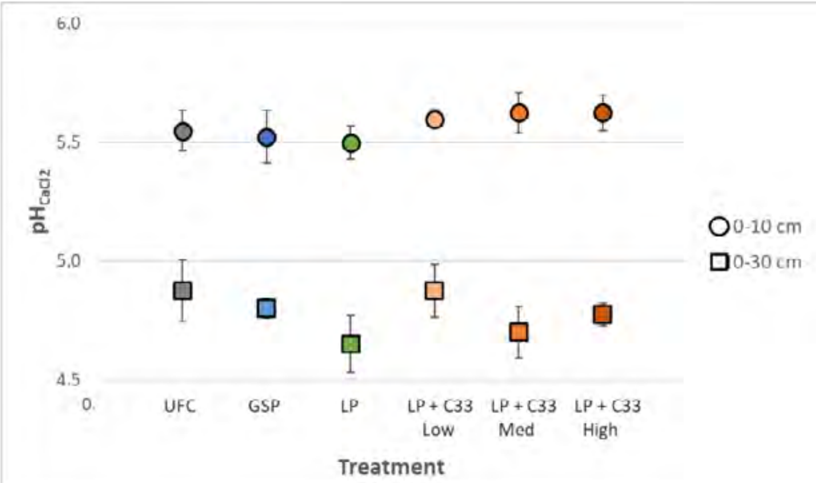
Soil pH

Soil pH was significantly higher in the top 10 cm soil layer compared with the top 30 cm soil horizon (P < 0.001). For the top 10 cm, there were minor increases in soil pH (on average 0.1 pH units) for treatments that contained C33 compared to grower standard practice. Across the top 30 cm of soil, only the LP + C33 Low treatment achieved a modest improvement in pH (by 0.08 pH units) compared with the grower standard practice. The relatively stable soil pH across treatments suggests that additional N fertiliser did not contribute to soil acidification here. Of concern, however, are the lower soil pH values for the top 30 cm horizon. These values could be indicative of subsoil acidity at this site, which may have hindered root exploration and nutrient uptake. This combined with low S concentrations possibly contributed to the relatively low yields here.



Conclusions

At this site, the Carbon Ag liquid program delivered up to 239 kg/ha more grain, higher net gains and ROI in three out of four treatments, and increased soil carbon by up to 0.46% or 598 kg/ha compared with standard practice. These are excellent results given the potentially yield-limiting subsoil pH and S deficiency encountered. Quairading is a good site to explore the dynamics of C levels and pH buffer through C33.

Appendix

Soil fertility (post-harvest)

Treatment No.	Treatment name	Depth (cm)	pH_{H2O}	pH_{CaCl2}	EC (dS/m)	NO_3-N (mg/kg)	PO_4-P (mg/kg)	K (mg/kg)	S (mg/kg)	C (%)
1	UFC	0-10	6.43	5.55	0.33	6.25	13.0	43.5	2.33	1.15
2	GSP	0-10	6.40	5.53	0.36	5.75	12.5	55.5	2.58	0.96
3	LP	0-10	6.43	5.50	0.39	8.80	14.3	46.3	2.60	1.03
4	LP + C33 low	0-10	6.40	5.60	0.39	10.0	14.0	45.3	2.28	1.27
5	LP + C33 med	0-10	6.45	5.63	0.40	8.50	12.5	24.5	2.55	1.42
6	LP + C33 high	0-10	6.45	5.63	0.37	6.00	13.0	44.8	2.08	1.00
1	UFC	0-30	5.88	4.88	0.23	2.25	8.75	38.3	2.70	0.53
2	GSP	0-30	5.80	4.80	0.26	2.75	11.3	44.0	3.03	0.48
3	LP	0-30	5.73	4.65	0.21	2.50	13.3	39.0	3.03	0.39
4	LP + C33 low	0-30	5.95	4.88	0.26	3.50	14.0	23.8	3.10	0.56
5	LP + C33 med	0-30	5.88	4.70	0.22	2.25	9.25	62.3	2.60	0.41
6	LP + C33 high	0-30	5.88	4.78	0.23	2.75	13.0	32.3	2.88	0.44

WITTENOOM HILLS TRIAL REPORT (WHEAT)

Aim

The aim of this wheat trial was to assess the effects of the Carbon Ag liquid fertiliser program with and without the addition of C33 carbon pellets on wheat growth and yields.

Trial location: Mic Fels, Wittenoom Hills, Western Australia

Soil type: Duplex sand over gravel

Paddock history: 2020: canola

Crop & sowing Date: Wheat (cv Sceptre) 75 kg/ha sown on the 21st of May 2021

Trial design and fertiliser applications

Seeding treatments

Treatment No.	Treatment name	Seed treatment	UAN (L/ha)	MAP (kg/ha)	MOP (kg/ha)	Power PK (L/ha)	C33 Pellets (kg/ha)	Bioactive (L/ha)
1	UFC	None	0	0	0	0	0	0
2	GSP	None	60	70	30	0	0	0
3	LP	ActivePrime	61	50	7	15	0	5
4	LP + C33 low	ActivePrime	61	50	7	15	30	5
5	LP + C33 med	ActivePrime	61	50	7	15	50	5
6	LP + C33 high	ActivePrime	61	50	7	15	70	5

UFC = unfertilised control; GSP = grower standard practice; LP = Carbon Ag liquid practice.

Foliar treatments

Treatment No.	Treatment name	*1st Foliar spray – 23/06/2021*				*2nd Foliar spray – 25/07/2021*			
		UAN (L/ha)	Power PK (L/ha)	Cereal Plus Max (L/ha)	Bioactive (L/ha)	UAN (L/ha)	Power PK (L/ha)	Cereal Plus Max (L/ha)	Bioactive (L/ha)
1	UFC	0	0	0	0	0	0	0	0
2	GSP	0	0	0	0	140	0	0	0
3	LP	100	5	3	4	140	2	2	2
4	LP + C33 low	100	5	3	4	140	2	2	2
5	LP + C33 med	100	5	3	4	140	2	2	2
6	LP + C33 high	100	5	3	4	140	2	2	2

UFC = unfertilised control; GSP = grower standard practice; LP = Carbon Ag liquid program.

Total nutrients applied

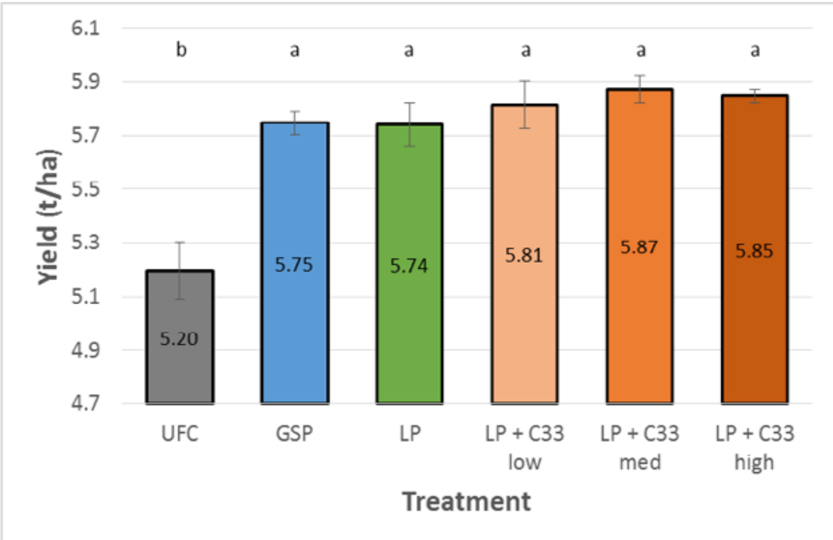
Treatment No.	Treatment name	N	P	K
1	UFC	0	0	0
2	GSP	91	16	15
3	LP	122	16	15
4	LP + C33 low	123	17	15
5	LP + C33 med	123	17	15
6	LP + C33 high	124	17	16

UFC = unfertilised control; GSP = grower standard practice; LP = Carbon Ag liquid practice.

Growing season rainfall: 267.8 mm

Yield

All fertilised treatments resulted in significantly higher yields than the unfertilised control (P ≤ 0.031). Modest yield increases occurred in the Carbon Ag LP + C33, with an additional 67 kg/ha to 126 kg/ha more grain, demonstrating feasibility of resupplying organic matter. The main difference between this trial and other Carbon Ag wheat trials in 2021 (ie, Latham and Quairading) was that the second foliar N spray was also applied to the grower standard practice. Foliar N as well as high standing N (nitrate of >6 mg/kg in unfertilised control furrow after harvest) may have been a factor increasing the GSP yield relative to other trials.



ROI

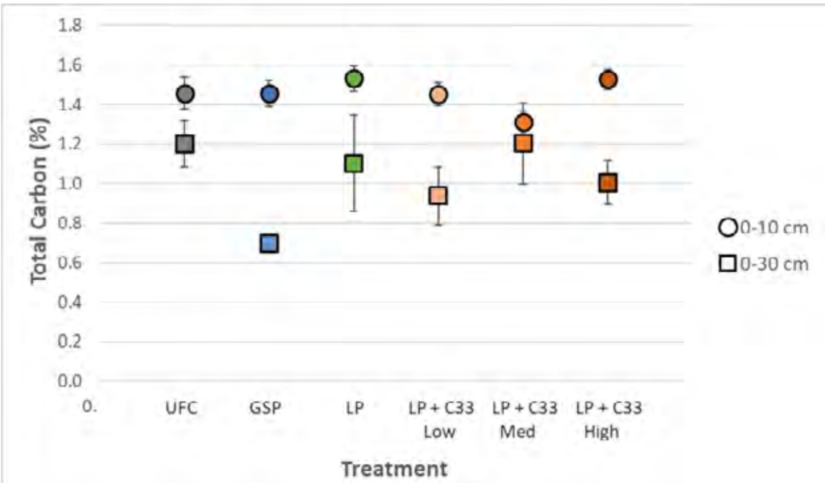
The Carbon Ag liquid program achieved slightly higher net gains (on average $50/ha) and ROI in three out of four treatments compared with the grower standard practice.

Treatment No.	Treatment name	Fertiliser input ($/ha)	Harvest income ($/ha)	Net gain ($/ha)	ROI (%)
1	UFC	$0	$1,975	$1,975	n/a‡
2	GSP	$758	$2,184	$1,427	188%
3	LP	$772	$2,182	$1,410	183%
4	LP + C33 low*	$772	$2,209	$1,438	186%
5	LP + C33 med*	$772	$2,232	$1,460	189%
6	LP + C33 high*	$772	$2,222	$1,450	188%

**Note, the cost of C33 was not included in these calculations as C33 is designed to build soil carbon, which is a long-term investment in soil health. ‡ ROI for the unfertilised control cannot be calculated due to division by zero. Transport costs and other crop protection products were excluded in the net gain and ROI calculations. Calculations are based on a wheat price of $380/t.*

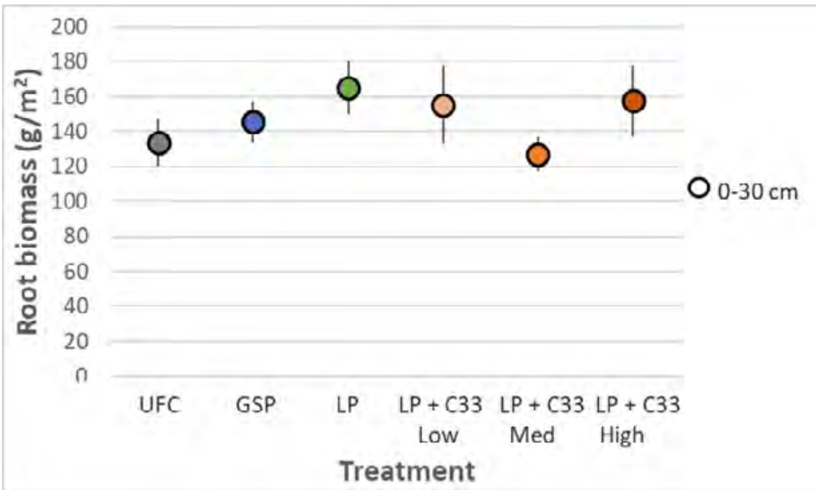
Total soil carbon (post-harvest)

Overall, carbon concentrations were significantly higher in the top 10 cm (on average 1.46%) compared with the top 30 cm of the soil (on average 1.02%, P < 0.001). Interestingly, the grower standard practice showed a marked decrease of soil carbon across the 0-30 cm soil horizon, compared to LP and LP + C33 treatments as well as the unfertilised control. These fertiliser practices increased yield and total carbon, equating to C of 312 kg/ha to 657 kg/ha in the top 30 cm.



Root biomass (post-harvest)

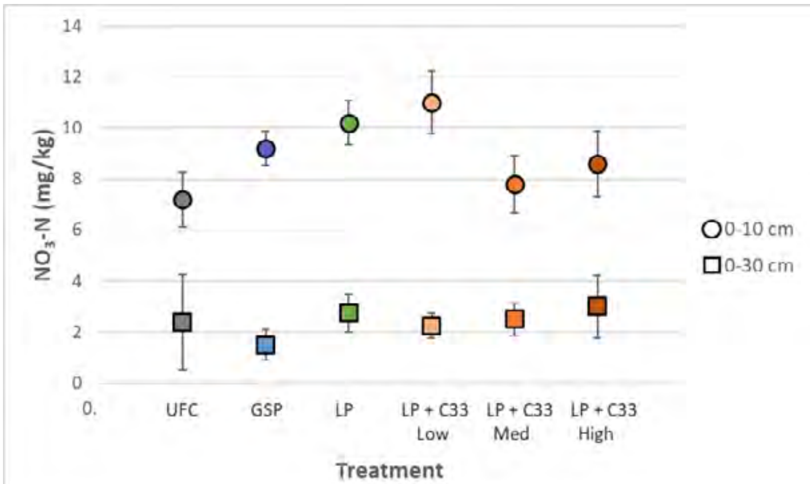
Root biomass was increased in treatments LP, LP + C33 Med and High by an average 10% compared with the grower standard practice. The lower root biomass determined for LP + C33 Low are somewhat surprising given the increased soil carbon values for these treatments.



Soil fertility (post-harvest)

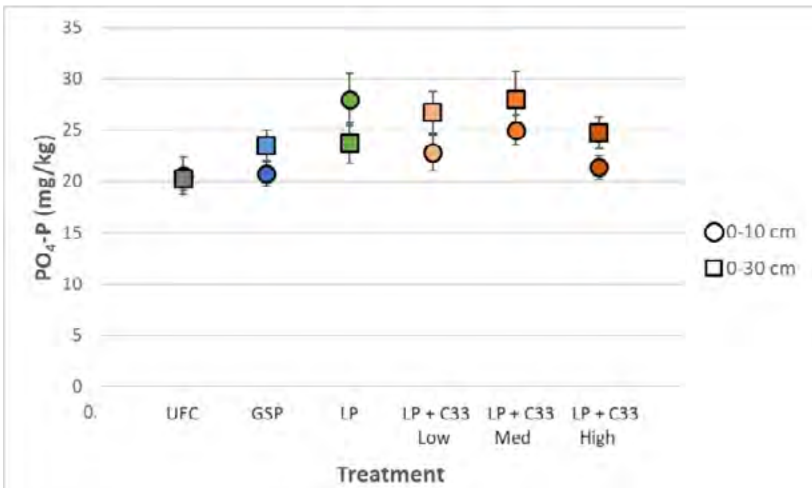
Nitrate-N

Nitrate concentrations were significantly higher in the top 10 cm compared to the top 30 cm ($P < 0.001$). In the 0-10 cm soil horizon, nitrate was higher for LP and LP +C33 Low by 1.0 mg/kg and 1.8 mg/kg respectively. Interestingly, the lower nitrate concentrations in LP C33 Med and LP C33 High coincided with higher yields at this site, possibly explaining the additional N usage. In contrast, nitrate was lowest in the grower standard practice across the top 30 cm soil horizon, which followed the carbon trend for this treatment.



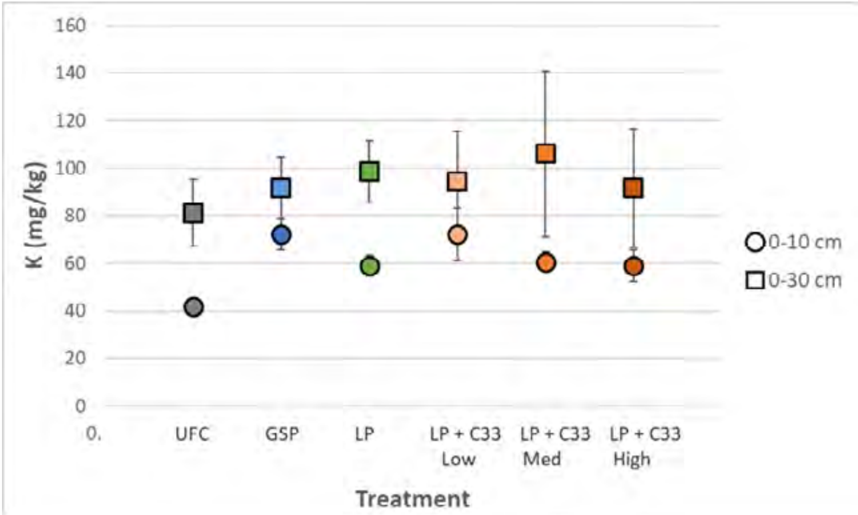
Phosphate-P

Phosphate concentrations across the two soil horizons were not too dissimilar. The Carbon Ag liquid fertiliser program achieved consistently higher P concentrations in both the top 10 cm and top 30 cm of soil. This will help with next season's crop given the fairly high residual concentrations of this commonly yield-limiting soil nutrient.



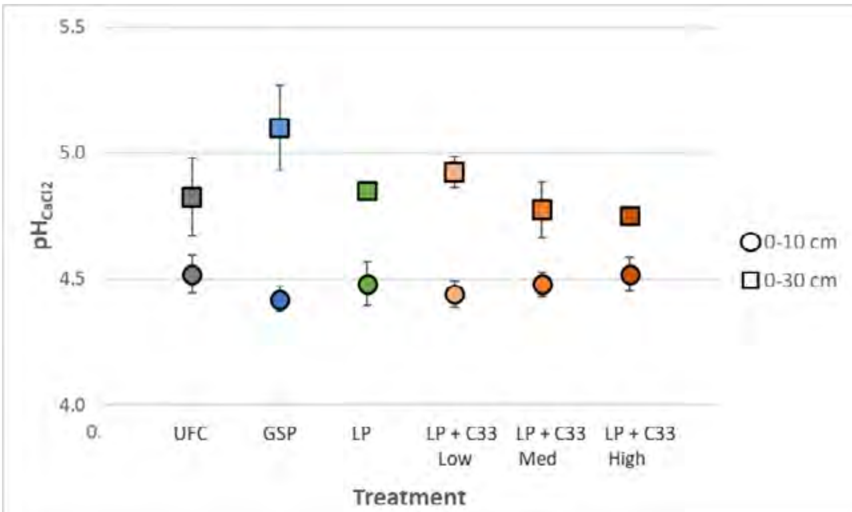
Potassium

Unlike at other trials sites, K was higher on the top 30 cm of soil than in the top 10 cm ($P < 0.001$). In the 0-10 cm soil horizon, the K concentrations in the unfertilised control were significantly lower than in the grower standard practice and LP + C33 ($P \leq 0.036$). In the top 30 cm horizon, the Carbon Ag liquid program added an additional 5.9 mg/kg K to the soil.



Soil pH

Similar to K, soil pH was higher in the top 30 cm than in the top 10 cm. This is in stark contrast to all other trial sites. In the top 10 cm, pH values around 4.5 were significantly lower than in the top 30 cm ($P < 0.001$). This may have hindered root exploration and nutrient availability here, despite a 5 to 6 t/ha crop. In the top 30 cm, the grower standard practice stood out as it had the highest pH.



Conclusions

This trial achieved comparatively high grain yields despite low topsoil pH values. This is especially true for the unfertilised control, which may suggest that soil fertility was very high at seeding, specifically N and P. As such, the fertiliser applications in the grower standard practice and the Carbon Ag liquid program could not significantly increase yield and net gains and ROI were quite similar.

Appendix

Soil fertility (post-harvest)

Treatment No.	Treatment name	Depth (cm)	pH_{H2O}	pH_{CaCl2}	EC (dS/m)	NO_3-N (mg/kg)	PO_4-P (mg/kg)	K (mg/kg)	S (mg/kg)	C (%)
1	UFC	0-10	5.66	4.52	0.05	7.20	20.6	42.0	3.70	1.46
2	GSP	0-10	5.56	4.42	0.07	9.20	20.8	72.2	2.90	1.46
3	LP	0-10	5.60	4.48	0.07	10.2	28.0	59.0	3.54	1.53
4	LP + C33 low	0-10	5.52	4.44	0.07	11.0	22.8	72.2	3.84	1.45
5	LP + C33 med	0-10	5.60	4.48	0.06	7.80	25.0	60.6	3.60	1.31
6	LP + C33 high	0-10	5.56	4.52	0.07	8.60	21.4	59.2	3.52	1.53
1	UFC	0-30	6.25	4.83	0.04	2.38	20.3	81.3	1.83	1.20
2	GSP	0-30	6.53	5.10	0.04	1.50	23.5	91.8	1.50	0.70
3	LP	0-30	6.30	4.85	0.05	2.75	23.8	98.5	1.35	1.10
4	LP + C33 low	0-30	6.30	4.93	0.04	2.25	26.8	94.3	1.38	0.94
5	LP + C33 med	0-30	6.10	4.78	0.05	2.50	28.0	106	1.90	1.20
6	LP + C33 high	0-30	6.15	4.75	0.04	3.00	24.8	91.8	1.45	1.01

NORTHAM TRIAL REPORT (CANOLA)

Aim

The aim of this canola trial was to assess the effects of the Carbon Ag liquid fertiliser program with and without the addition of C33 carbon pellets on wheat growth and yields.

Trial location: Andrew Knipe, Northam, Western Australia

Soil type: Heavy gravel loam

Paddock history: 2020:

Crop & sowing Date: Canola 2.5 kg/ha sown on the 14th of May 2021

Trial design and fertiliser applications

Seeding treatments

Treatment No.	Treatment name	Seed treatment	UAN (L/ha)	MAP (kg/ha)	MOP (kg/ha)	Power PK (L/ha)	C33 Pellets (kg/ha)	Bioactive (L/ha)
1	UFC	None	0	0	0	0	0	0
2	GSP	None	70	45	35	0	0	0
3	LP	BSN10	77	25	12	15	0	5
4	LP + C33 low	BSN10	77	25	12	15	30	5
5	LP + C33 med	BSN10	77	25	12	15	40	5
6	LP + C33 high	BSN10	77	25	12	15	50	5

UFC = unfertilised control; GSP = grower standard practice; LP = Carbon Ag liquid practice.

Foliar treatments

		1st Foliar spray – 14/07/2021				*2nd Foliar spray – 30/07/2021*				*3rd Foliar spray – 27/08/2021*
Treatment No.	Treatment name	UAN (L/ha)	Power PK (L/ha)	Cereal Plus Max (L/ha)	Bioactive (L/ha)	UAN (L/ha)	Power PK (L/ha)	Cereal Plus Max (L/ha)	Bioactive (L/ha)	UAN (L/ha)
1	UFC	0	0	0	0	0	0	0	0	0
2	GSP	0	0	0	0	140	0	0	0	0
3	LP	100	5	3	4	140	2	2	2	150
4	LP + C33 low	100	5	3	4	140	2	2	2	150
5	LP + C33 med	100	5	3	4	140	2	2	2	150
6	LP + C33 high	100	5	3	4	140	2	2	2	150

UFC = unfertilised control; GSP = grower standard practice; LP = Carbon Ag liquid program.

Total nutrients applied

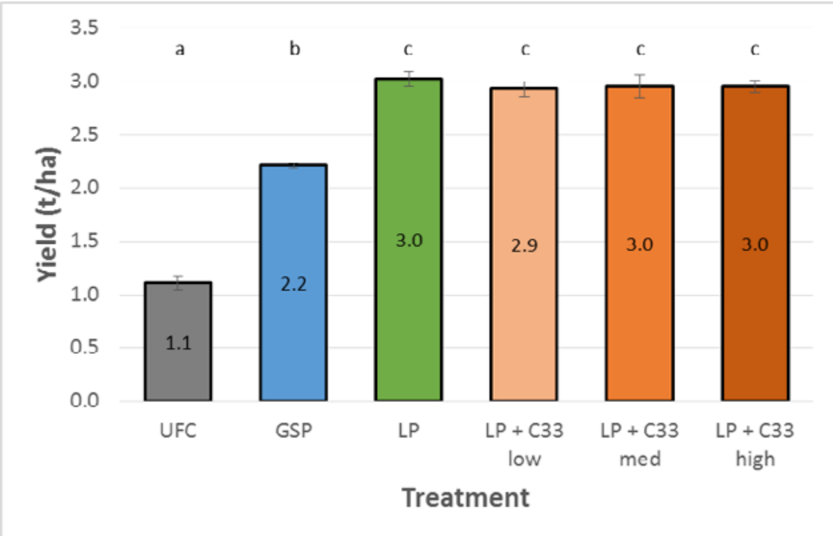
Treatment No.	Treatment name	N	P	K
1	UFC	0	0	0
2	GSP	75	10	17
3	LP	173	13	21
4	LP + C33 low	173	13	22
5	LP + C33 med	174	13	22
6	LP + C33 high	174	13	22

UFC = unfertilised control; GSP = grower standard practice; LP = Carbon Ag liquid practice.

Growing season rainfall: 387 mm

Yield

The Carbon Ag liquid program consistently delivered significantly higher yields than both the unfertilised control and the grower standard practice (one-way ANOVA $P < 0.001$). The Carbon Ag liquid program, with or without the C33 pellet, achieved on average 758 kg/ha or 34% more yield than grower standard practice ($P \leq 0.027$, LSD = 0.722 t/ha). In a good rainfall year, the added N delivered by the Carbon Ag liquid program appeared the key to achieving higher yields than the grower standard practice. The grower standard practice achieved twice the yield of the unfertilised control ($P < 0.001$, LSD = 1.100 t/ha). This may indicate that the initial soil fertility (specifically N) was low at this trial site and sufficient nutrients needed to be supplied to reach the yield potential.



ROI

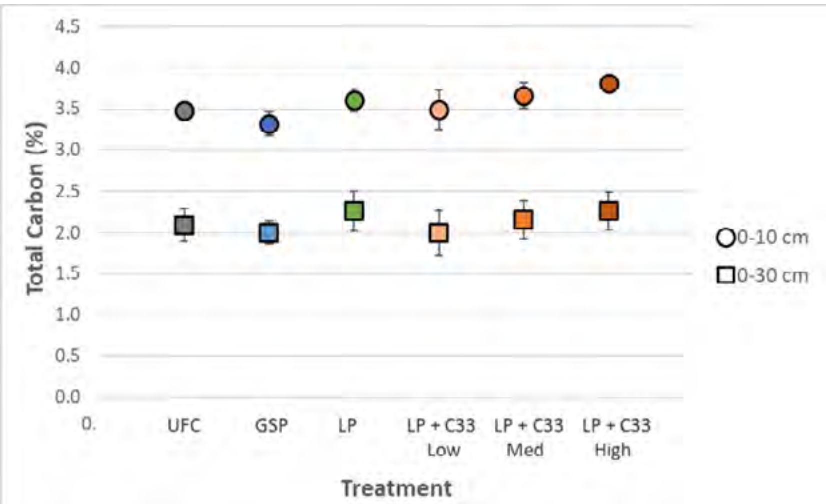
The Carbon Ag liquid program achieved higher net gains (on average $494/ha) than the grower standard practice. However, because of the larger input costs of the Carbon Ag program, the ROI was higher for the grower standard practice.

Treatment No.	Treatment name	Fertiliser input ($/ha)	Harvest income ($/ha)	Net gain ($/ha)	ROI (%)
1	UFC	$0	$3,343	$3,343	n/a‡
2	GSP	$618	$4,738	$4,120	667%
3	LP	$817	$5,442	$4,625	566%
4	LP + C33 low*	$817	$5,320	$4,503	551%
5	LP + C33 med*	$817	$5,441	$4,624	566%
6	LP + C33 high*	$817	$5,522	$4,705	576%

**Note, the cost of C33 was not included in these calculations as C33 is designed to build soil carbon, which is a long-term investment in soil health. ‡ ROI for the unfertilised control cannot be calculated due to division by zero. Transport costs and other crop protection products were excluded in the net gain and ROI calculations. Calculations are based on a canola price of $1,000/t.*

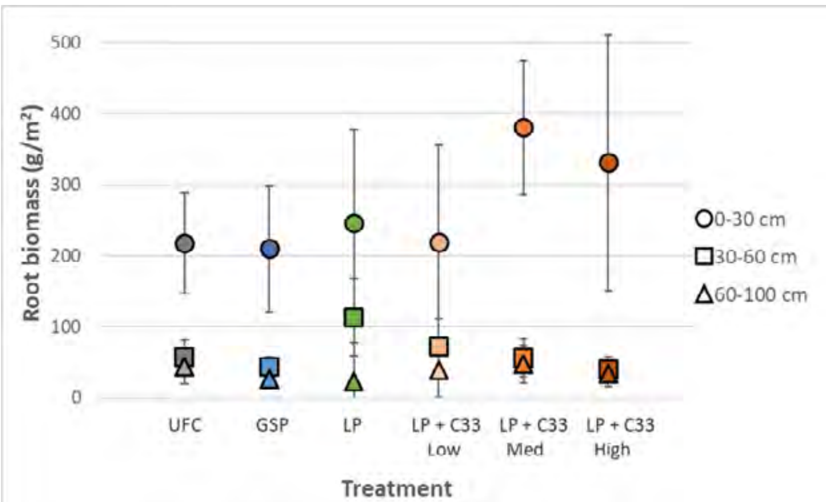
Total soil carbon (post-harvest)

Soil carbon in the top 10 cm was higher in all treatments after harvest when compared to the grower standard practice. There was a sign of soil carbon increase in the furrow with C33 pellets. The Carbon Ag liquid program with 50 kg/ha of C33 pellets showed an increase of 0.49% total carbon. This equals an additional 637 kg/ha of carbon on the soil. Across the top 30 cm of soil, there were no changes to carbon concentrations due to treatment differences.



Root biomass (post-harvest)

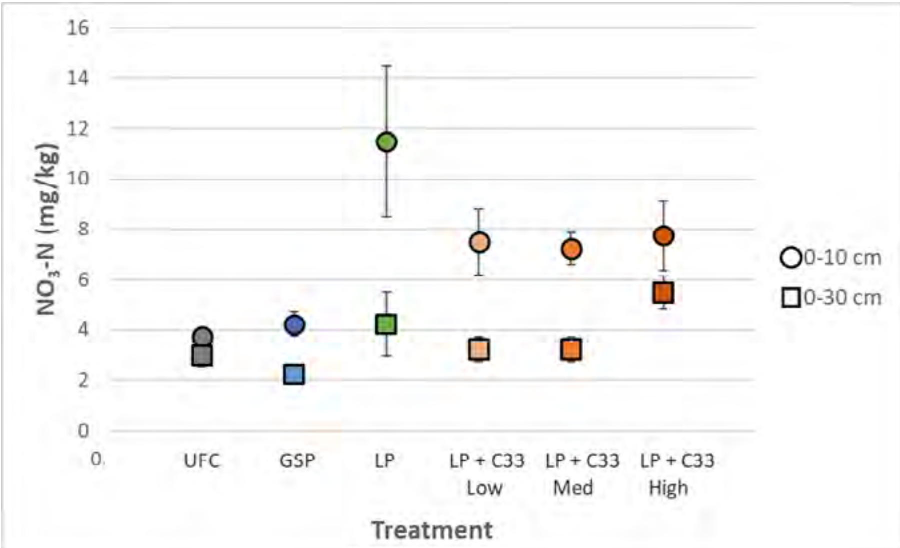
Root mass density was higher in the top 30 cm of the soil profile than in deeper layers (P = 0.001). There were no significant treatment differences given the large variability of the data, especially in the top 30 cm. Root biomass was explored to a depth of 1m in this survey, and root growth always extended below this layer.



Soil fertility (post-harvest)

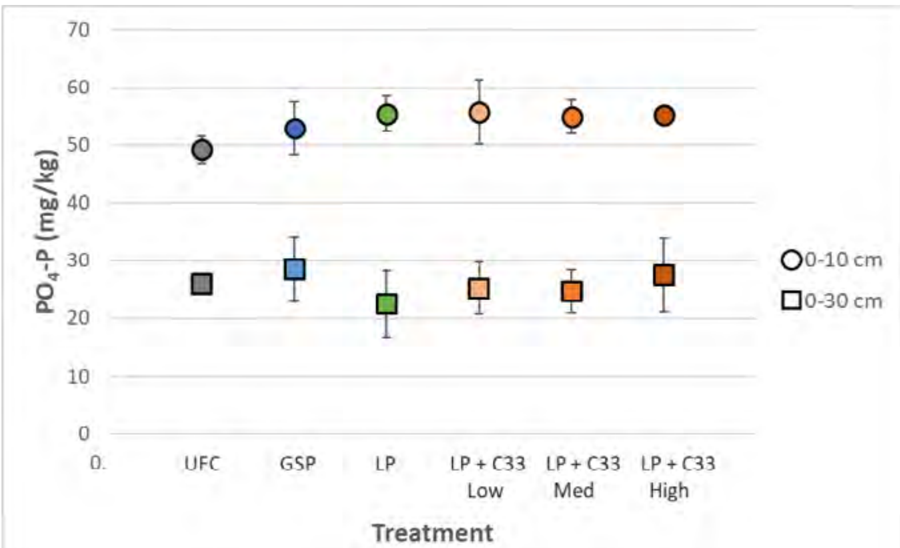
Nitrate-N

Nitrate concentrations in the top 10 cm were greater under the Carbon Ag liquid program compared with the unfertilised control and grower standard practice. Due high data variance, the only significant differences occurred between the unfertilised control and LP + C33 Med (40 kg/ha; P = 0.039). Across the top 30 cm, soil nitrate concentrations were also higher than in the standard practice. Treatment LP + C33 High (50 kg/ha) showed a significant increase over grower standard practice (P = 0.029), which may indicate a higher leaching potential for N in this soil type.



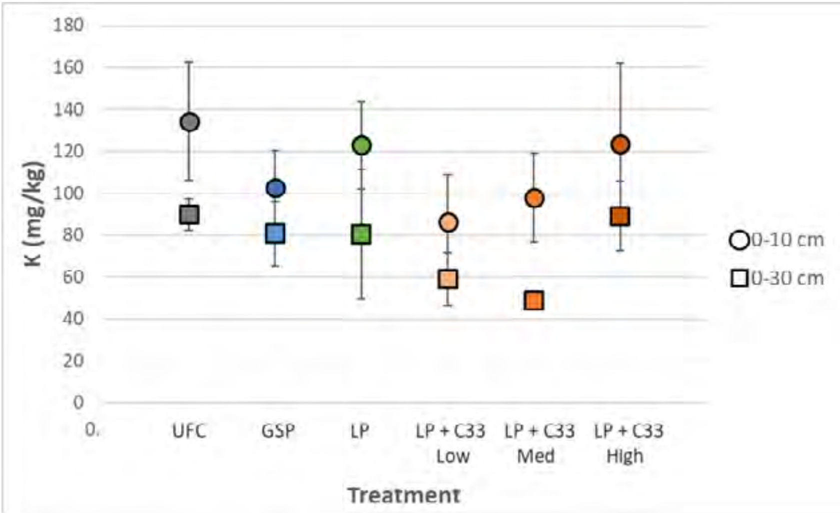
Phosphate-P

The Carbon Ag liquid program resulted in on average 2.4 mg/kg more P in the top 10 cm of soil. This was a marginal improvement on the grower standard practice. On average 3.5 mg/kg less P was detected in the top 30 cm of soil in the Carbon Ag liquid program compared with grower standard practice. This suggests that foliar applied liquid P does not move vertically in the soil profile and will be available for next year's crop.



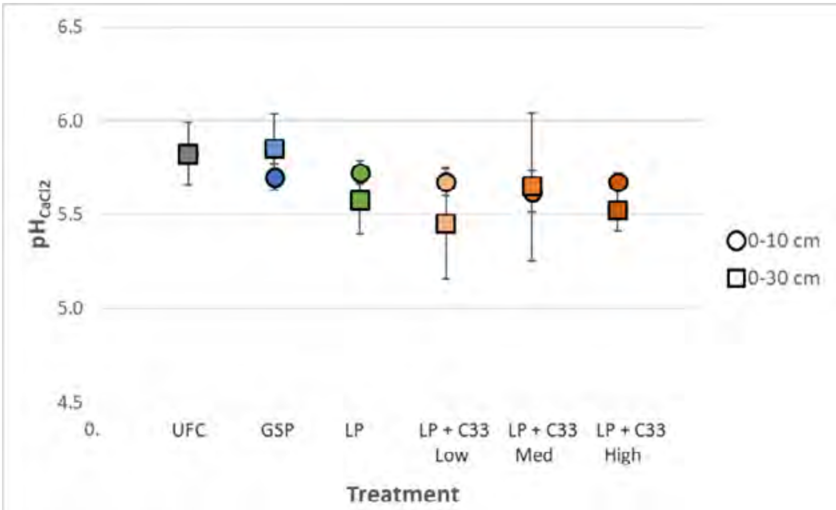
Potassium

Potassium concentrations were relatively high, with the unfertilised control showing highest levels in both soil horizons. This suggests that unfertilised plants required less of this nutrient than plants that received both N and P. Balancing nutrition correctly is vital as it avoids excess fertiliser being applied without introducing deficiencies.



Soil pH

Soil pH_{CaCl2} varied between pH 5.4 and pH 5.9 with no significant treatment differences. There was a trend for slightly decreased soil pH in treatments that received higher N inputs. This is a common phenomenon that can be mitigated by lime addition ie, via traditional spreading of lime or by incorporating the novel Carbon Ag carbon pellet that includes lime, gypsum or dolomite, now available for the 2022 season.



Conclusions

A good rainfall year and a dynamic response to the season enabled by the Carbon Ag liquid fertiliser program delivered on average 758 kg/ha more yield compared with the grower standard practice of the district. This resulted in higher net gains (on average $494/ha) from the Carbon Ag program compared with the grower standard practice. The Carbon Ag liquid program, combined with the C33 pellets, helped increase soil carbon levels by up to 637 kg/ha in the first year of trials at this site. More soil carbon means better soil water retention, potential carbon sequestration, and general increased soil health. These are encouraging results that can be built upon by continuing the trial in the same location over the coming years.

Appendix

Soil fertility (post-harvest)

Treatment No.	Treatment name	Depth (cm)	pH_{H2O}	pH_{CaCl2}	EC (dS/m)	NO_3-N (mg/kg)	PO_4-P (mg/kg)	K (mg/kg)	S (mg/kg)	C (%)
1	UFC	0-10	6.80	5.83	0.06	3.75	49.3	135	10.3	3.48
2	GSP	0-10	6.63	5.70	0.05	4.25	53.0	103	12.0	3.32
3	LP	0-10	6.58	5.73	0.06	11.5	55.5	123	13.6	3.61
4	LP + C33 low	0-10	6.58	5.68	0.08	7.50	55.8	86.3	12.9	3.49
5	LP + C33 med	0-10	6.55	5.63	0.07	7.25	55.0	98.0	13.7	3.66
6	LP + C33 high	0-10	6.63	5.68	0.08	7.75	55.3	124	15.1	3.81
1	UFC	0-30	6.73	5.83	0.08	3.00	26.0	90.0	26.1	2.09
2	GSP	0-30	6.65	5.85	0.06	2.25	28.5	80.8	31.3	2.00
3	LP	0-30	6.45	5.58	0.08	4.25	22.5	80.5	27.3	2.26
4	LP + C33 low	0-30	6.43	5.45	0.06	3.25	25.3	59.0	24.3	1.99
5	LP + C33 med	0-30	6.35	5.65	0.10	3.25	24.8	48.8	44.2	2.16
6	LP + C33 high	0-30	6.43	5.53	0.07	5.50	27.5	89.0	28.6	2.26

Overall conclusions and outlook

The Carbon Ag liquid fertiliser program allowed the additional application of foliar fertilisers during a good growing season. This maximised yields in three out of the four small plot, agronomic trials compared with grower standard practice of the corresponding district. Consequently, the Carbon Ag program frequently delivered higher net gains and ROI. In the remaining trial (Wittenoom Hills), the Carbon Ag program achieved similar results in terms of yield and ROI as the grower standard practice.

Uniquely, we integrated nutrient testing, soil C and root biomass measurement after harvest within the trials. This increased functional understanding of the effects of tuning inputs to soil type, nutrient bank and climatic conditions. Such information also adds to the scope of understanding of current soil organic matter and the potential to increase soil carbon.

Considering this was the first year of trials for this particular program and in each of the locations, the results are very encouraging and can be further improved in future years.

In addition to increasing yields and farm income, the Carbon Ag program also increased soil carbon and soil fertility in many carbon ages. This means nutrient mining (negative nutrient balance) was avoided and the soil-stored nutrients will be available for next year's crop.