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Amelioration of subsoil acidity using organic amendments

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Key findings

- The crop responded to nutrients rather than improvements in soil acidity in the establishment year.
- Grain yield was higher under the lucerne hay pellets and poultry litter treatments compared with other treatments. There was no yield improvement with the lime treatment compared with the nil treatment in the first year.
- Nitrogen content in plant tissues was higher, compared with other organic amendments, at seedling stage and at anthesis under the lucerne hay pellets and poultry litter treatments due to their high nutrient contents.

Introduction

A field experiment focusing on organic amendments was established on a highly acidic soil in 2018 and will be monitored over next three years.

Site details

Location	Billa, Holbrook NSW
Soil type	Yellow chromosol (Isbell 1996)
Previous crops	2015 Hyola® 970CL canola 2016 EGA Wedgetail⦶ wheat 2017 EGA Wedgetail⦶ wheat
Crop in 2018	Grazing canola (SF Edimax CL)
Fallow rainfall (November–March)	2018 (292 mm), long-term average (409 mm)
In-crop rainfall (April–October)	2018 (214 mm), long-term average (388 mm)
Fertiliser at sowing	60 kg/ha mono-ammonium phosphate (MAP) with 11% nitrogen (N), 22.7% phosphorus (P), 2% sulfur (S)
Top-dressing fertiliser (urea)	50 kg N/ha as urea
Ripping machine	3-D Ripper (5 tynes), designed and fabricated by NSW DPI (Li and Burns 2016)
Ripping width and depth	50 cm between rip lines; to 30 cm deep

Treatments	There are nine treatment contrasts, with and without lime, focusing on organic amendments (Table 1). Two additional treatments are a nil amendment treatment as a control and a rip-only treatment to assess ripping effects. All treatments were surface limed to pH 5.0 at 0–10 cm except for Treatment 1with no lime and Treatment 3 with a high lime rate (limed to pH 5.5). All surface lime was applied after deep ripping with amendments, then incorporated into 0–10 cm. Plot size: 5 × 20 m = 100 m^2. Buffer between plots: 2.5 m, buffer between blocks: 20 m.

Table 1. Treatment description and amendments.

ID	Treatment[A]	Description	Organic amendment rate	Other additives	Lime rate (t/ha)		Target pH	Note[A]
					0–10 cm	10–30 cm		
1	Nil amendment	No amendment			–	–	No lime at surface	Control treatment
2	Deep rip only	Ripped to 30 cm			1.5	–	Surface pH 5.0	To assess ripping effect
3	Surface lime	Surface liming			2.8	–	Surface pH 5.5	Treatment contrast 1 Surface vs deep lime
4	Deep lime	Applied at 10–30 cm			1.5	2.6	pH 5.0 at 0–30 cm	
5	Deep lucerne hay	Applied at 10–30 cm	15 t/ha		1.5	–	pH 5.0 at 0–10 cm	Treatment contrast 2 Lucerne hay with and without lime
6	Deep lucerne hay with lime	Applied at 10–30 cm	15 t/ha		1.5	2.6	pH 5.0 at 0–30 cm	
7	Deep pea hay	Applied at 10–30 cm	15 t/ha		1.5	–	pH 5.0 at 0–10 cm	Treatment contrast 3 Pea hay with and without lime
8	Deep pea hay with lime	Applied at 10–30 cm	15 t/ha		1.5	2.6	pH 5.0 at 0–30 cm	
9	Deep wheat straw	Applied at 10–30 cm	15 t/ha		1.5	–	pH 5.0 at 0–10 cm	Treatment contrast 4 Wheat straw with and without lime
10	Deep wheat straw with lime	Applied at 10–30 cm	15 t/ha		1.5	2.6	pH 5.0 at 0–30 cm	
11	Deep wheat straw plus NPS[B]	Applied at 10–30 cm	15 t/ha	NPS	1.5	–	pH 5.0 at 0–10 cm	Treatment contrast 5 Wheat straw plus NPS with and without lime
12	Deep wheat straw plus NPS[B] with lime	Applied at 10–30 cm	15 t/ha	NPS	1.5	2.6	pH 5.0 at 0–30 cm	
13	Deep NPS[B]	Applied at 10–30 cm		NPS	1.5	–	pH 5.0 at 0–10 cm	Treatment contrast 6 Nutrients with and without lime
14	Deep NPS[B] with lime	Applied at 10–30 cm		NPS	1.5	2.6	pH 5.0 at 0–30 cm	
15	Deep poultry litter	Applied at 10–30 cm	15 t/ha		1.5	2.6	pH 5.0 at 0–10 cm	Treatment contrast 7 Poultry litter with and without lime
16	Deep poultry litter with lime	Applied at 10–30 cm	15 t/ha		1.5	2.6	pH 5.0 at 0–30 cm	
17	Deep biochar[C]	Applied at 10–30 cm	10 t/ha	Biochar	1.5	2.6	pH 5.0 at 0–10 cm	Treatment contrast 8 Biochar with and without lime
18	Deep biochar[C] with lime	Applied at 10–30 cm	10 t/ha	Biochar	1.5	2.6	pH 5.0 at 0–30 cm	
19	Deep RPR[D] 2	Applied at 10–30 cm	2 t/ha	RPR	1.5	–	pH 5.0 at 0–10 cm	Treatment contrast 9 High RPR vs. low RPR
20	Deep RPR[D] 4	Applied at 10–30 cm	4 t/ha	RPR	1.5	–	pH 5.0 at 0–10 cm	

[A] All organic amendments (lucerne hay, pea hay, wheat straw, poultry litter and biochar) were pelletised prior to implementation.
[B] NPS (nitrogen [N], phosphorus [P], sulfur [S]), 5 kg N/t, 2 kg P/t and 1.3 kg S/t as per Kirkby et al. (2013).
[C] Biochar was pelletised with pea hay (50:50).
[D] RPR, Reactive phosphate rock.

Results and discussion

Rainfall pattern

It was extremely dry in 2018, particularly in spring with only 22.5 mm and 27.0 mm of rainfall in September and October. The growing season rainfall was only 214 mm from April to October whereas the long-term average is 388 mm (Figure 1).

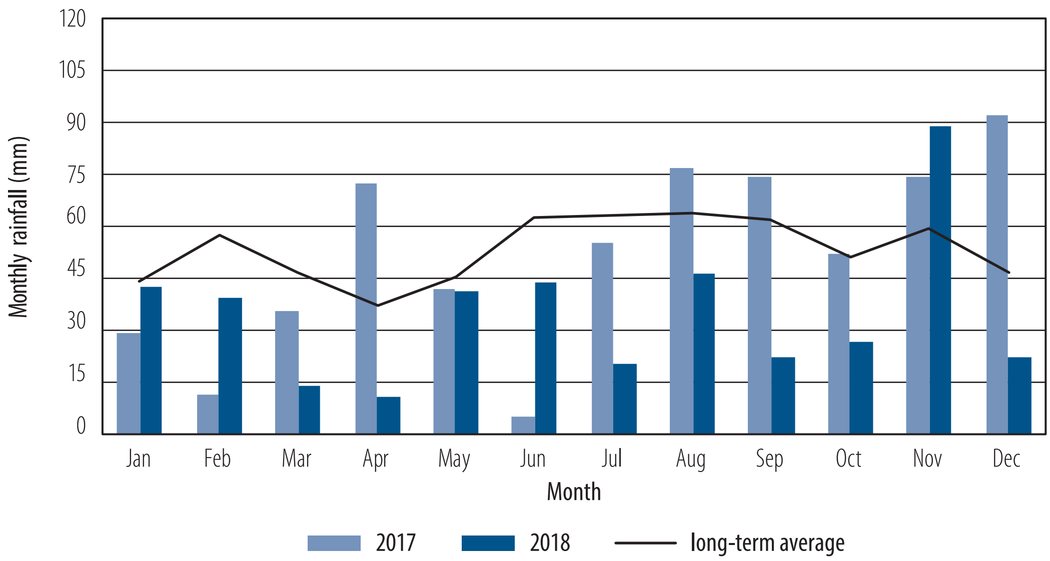

Figure 1. Monthly rainfall and long-term average rainfall at Holbrook, NSW.

Soil chemical properties

There were no differences in soil pH and exchangeable aluminium (Al%) before treatment was implemented. Averaged across the site, the soil pH was 5.09, 4.09 and 4.24 at 0–10 cm, 10–20 cm and 20–30 cm with exchangeable Al% of 2.6%, 30. 9% and 18.9% at the corresponding depths (Figure 2). The Colwell P was 66.8, 22.3 and 7.1 mg/kg, while soil mineral N was 570, 14.8 and 11.7 kg/ha at 0–10 cm, 10–20 cm and 20–30 cm (Figure 2).

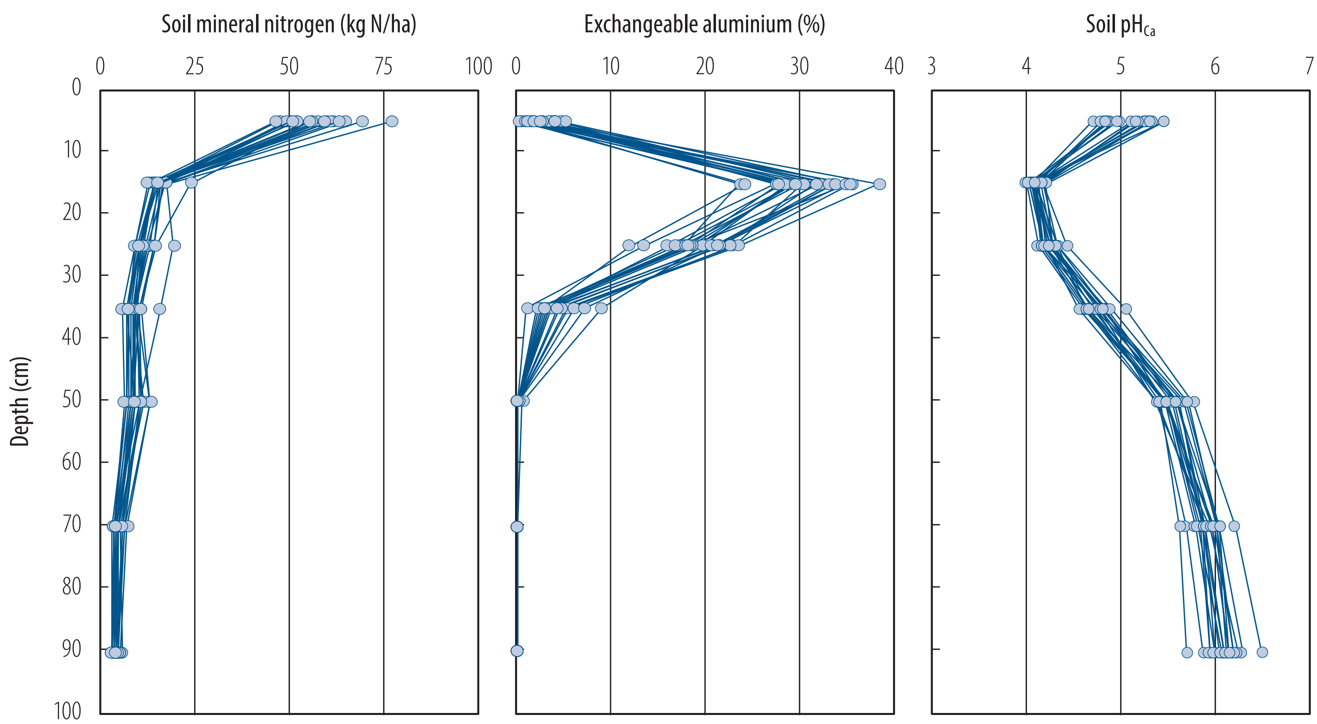

Figure 2. Baseline soil chemical analysis (soil mineral N, exchangeable Al% and pH_{Ca}) under designated treatments before treatment was imposed. No significant differences in any parameters at any depths.

Agronomic performance

The seedling number at establishment varied from eight to sixteen plants/m^2 across treatments (Figure 3), but there was no significant difference between treatments due to the large variation across the site.

There were significant differences in crop N content between treatments at seedling stage and at anthesis (Figure 4). Lucerne hay pellet treatments and poultry litter treatments had the highest crop N contents. Wheat straw without nutrients and biochar with pea hay had relatively low crop N contents, which was similar to the non-organic amendment treatments, such as the liming treatment and reactive phosphate rock (RPR) treatments.

At anthesis, the lucerne hay pellet treatment produced 9.6 t/ha of dry matter (DM), whereas the biochar with lime and the wheat straw treatment had only 5.2 t/ha of DM. Both poultry litter treatments had more than 8 t/ha of DM. The non-organic amendment treatments had similar DM at anthesis (Figure 5).

At harvest, grain yield followed a similar trend to anthesis DM. Lucerne hay pellet treatments with and without lime had the highest grain yield, close to 2 t/ha, followed by the poultry litter with lime treatment, whereas the deep lime treatment had similar grain yield to the control (nil amendment) treatment (Figure 5).

In general, the crop responded to nutrients, particularly N, rather than soil acidity amelioration in the first year after treatments were implemented. The higher N contents in plant tissues at seedling stage and at anthesis under lucerne hay pellets and poultry litter treatments were due to their high N contents. Grain yield was higher under lucerne hay pellets and poultry litter treatments compared with other treatments. In this first year, no yield improvement was found with lime compared with its pair treatment with any organic amendment.

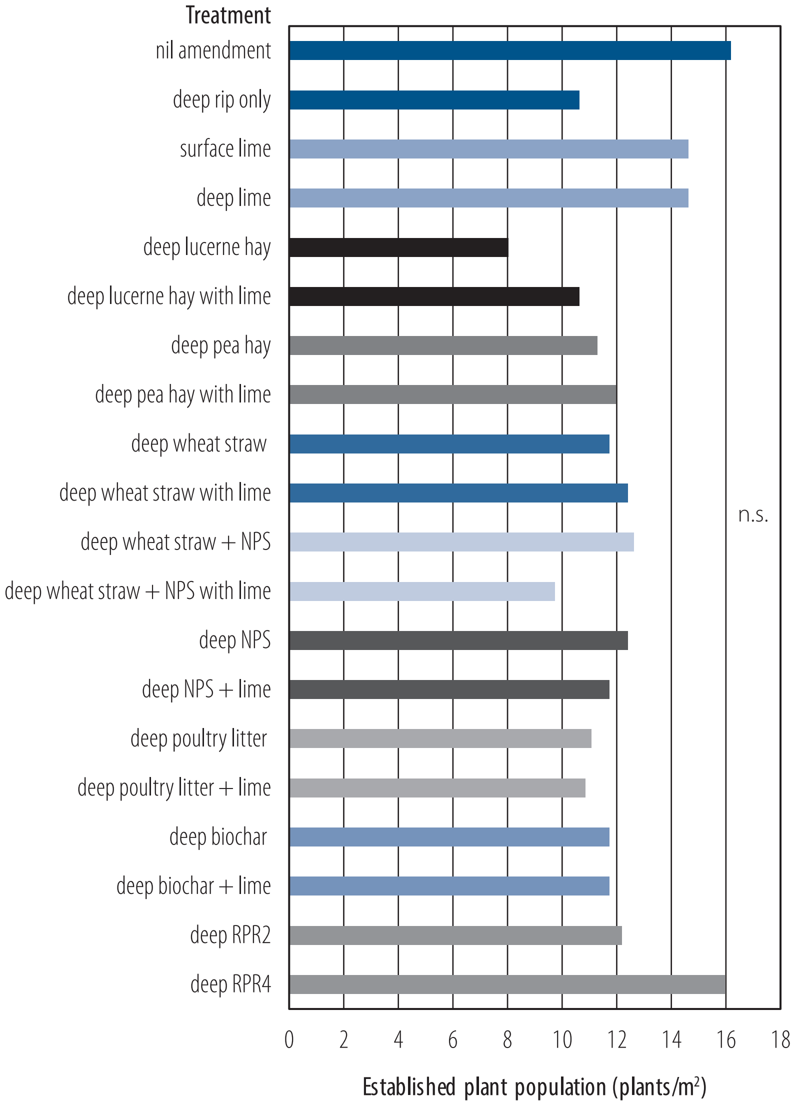

Figure 3. Seedling count (plants/m^2) at establishment under different treatments.

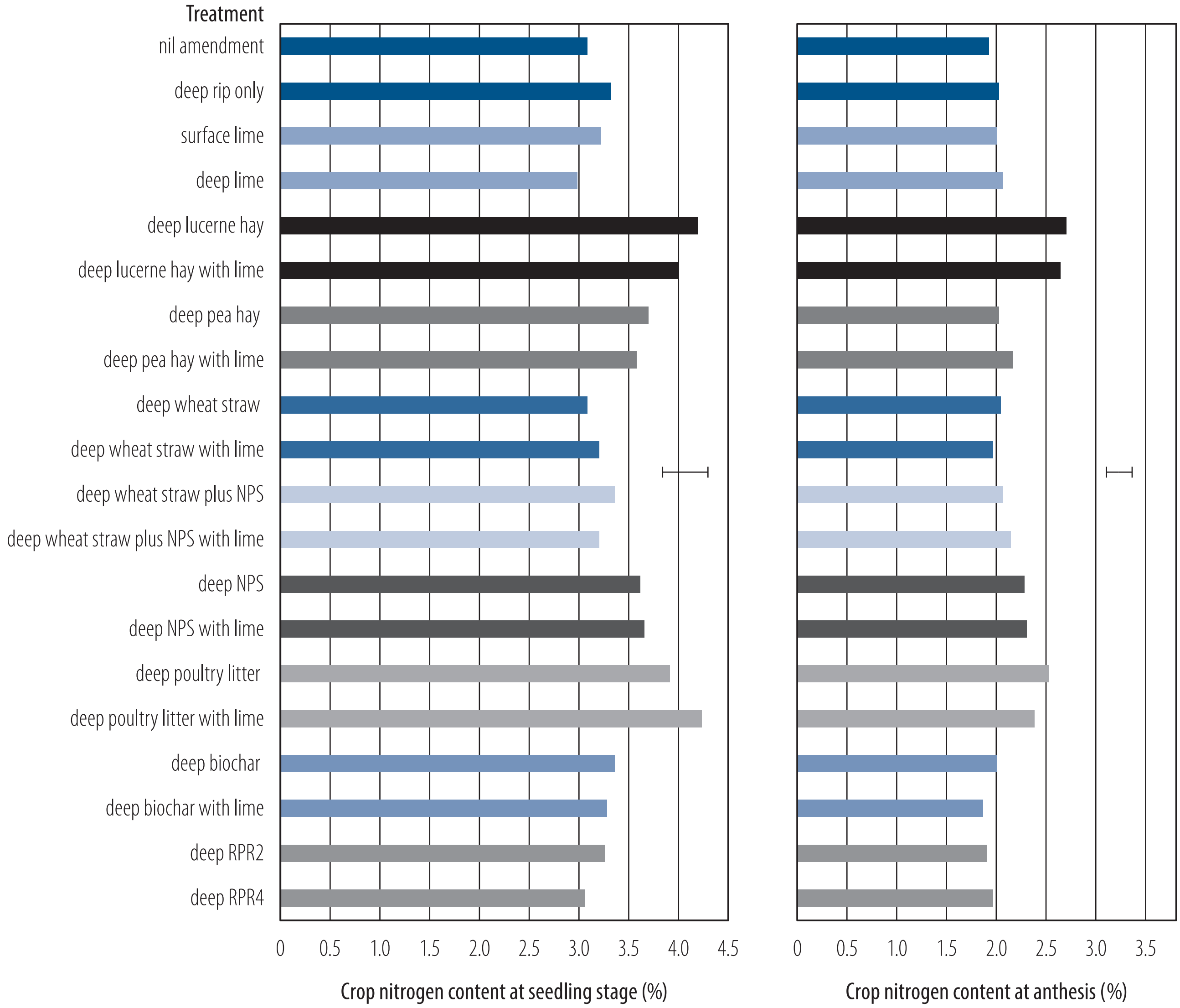

Figure 4. Nitrogen content (%) in plant tissue at seedling stage and at anthesis under different treatments.

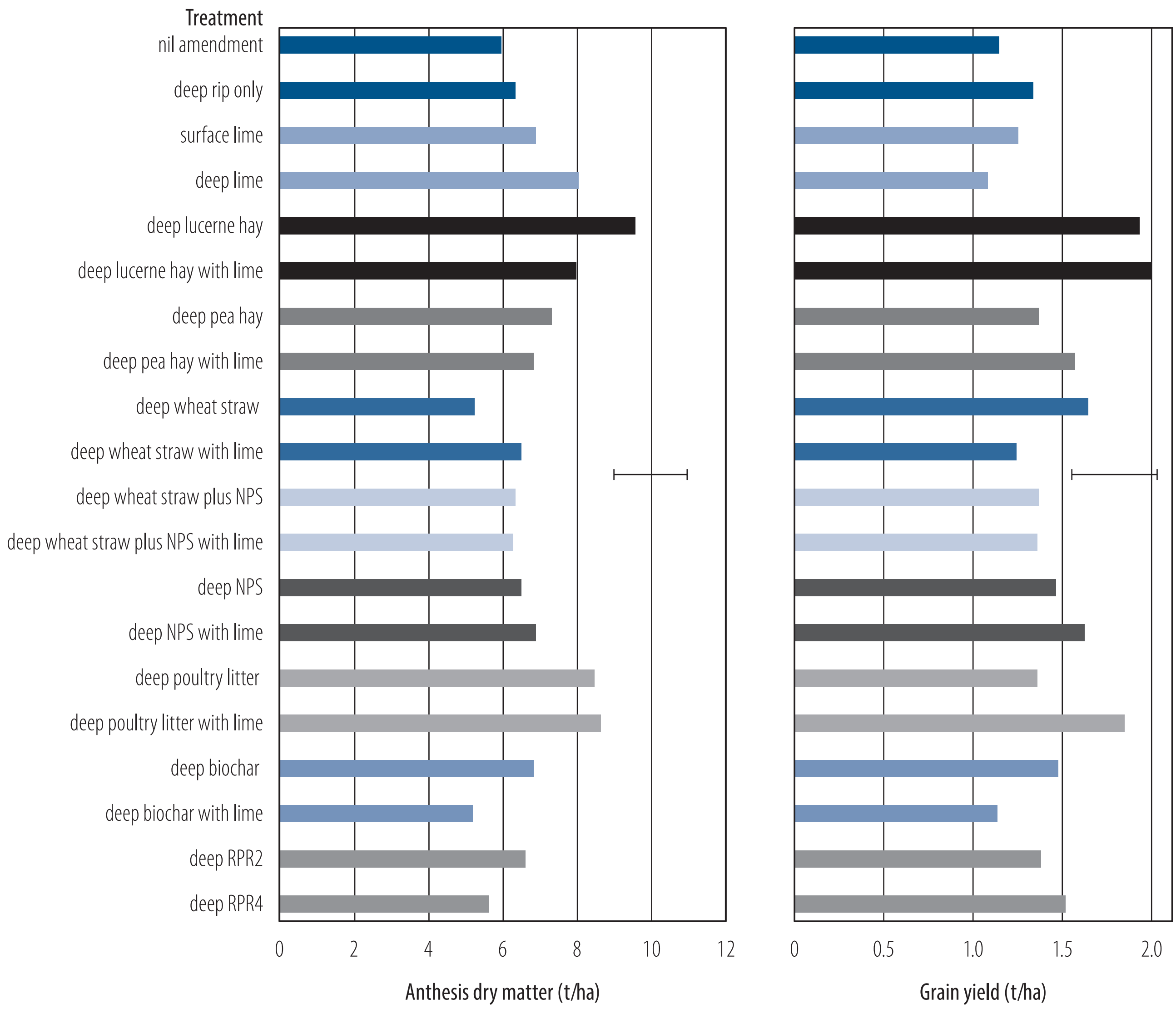

Figure 5. Crop dry matter at anthesis and grain yield at harvest under different treatments.

Conclusions

The crop responded to nutrients rather than improvements in soil acidity in the establishment year. Grain yield was higher under the lucerne hay pellets and poultry litter treatments compared with other organic amendments. There was no yield improvement with the lime treatment compared with the nil treatment in the first year.

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