Subsoil manuring with different organic manures increased canola yield in a dry spring

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Abstract
A field study was undertaken in 2007 to examine the effects of subsoil manuring, with different rates of organic amendments, on the growth and yield of a canola crop. The crop was grown on a Sodosol with dense sodic subsoil, in a high rainfall region (long-term average annual rainfall 576 mm) of Victoria. Amendments were applied at a rate of 5, 10 or 15 t/ha. Minimal rain fell during the late winter and early spring, but then significant rain fell in the late spring. The crop was sown late (mid June) and cool winter conditions delayed the germination and early growth of crop until spring. There were no treatment differences in canola biomass during vegetative growth or at anthesis. The control plots experienced water deficit stress during October and began to senesce. However the plots with organic amendments remained green during October, and were able to respond to the rain that fell in the late spring. All organic amendment treatments, apart from the low rate of pig manure, produced higher canola yields, than the control treatment. Yields generally increased linearly with increasing in rates of organic amendments. A key finding was that the poultry manure used in this study was equivalent in effectiveness to the lucerne pellets.

Key words
Canola, Deep ripping, Pig manure, Poultry Manure, Subsoil constraints

Introduction

There is now a widespread awareness that the dense clay subsoil in Sodosol soils can limit the performance of crops grown on these soils (Wong and Asseng 2007). The soils tend to become waterlogged on top of the relatively impermeable clay layer early in the growing season when winter rainfall exceeds evaporation (Gardner *et al*. 1992), and yet there may not be sufficient plant-available water above the clay for the crops to reach their potential yield at the end of the growing season, particularly if there is a dry finish to the season. It is not surprising therefore that many crops in the high rainfall zone (HRZ) of southern Australia do not yield more than one third of their potential (Riffkin and McNeil 2005).

Research from our laboratory has led to the development of subsoil manuring technology. This involves the placement of large quantities of organic amendment (such as 20 t/ha of lucerne or Dynamic Lifter® pellets) in the upper layers of the clay B horizon in Sodosol soils (Gill *et al.* 2009). Substantial increases in wheat yield (50-70%) and water extraction (up to 70 mm of additional subsoil water) from the clay subsoil during post-anthesis crop growth, have occurred at sites in the high rainfall zone of south west Victoria (Gill *et al.* 2008, 2009). These increases in crop performance were closely correlated with improvements in the physical properties of the subsurface layers that received the amendments (Gill *et al.* 2009). However the amendments used in these experiments were expensive and limited in availability. The issue is whether low-cost animal manures are effective as organic amendments for subsoil manuring. The manures are widely available in Victoria.

In this paper we discuss the effects of different rates (5, 10, and 15 t/ha) of pig and poultry manures, for their effects on the growth and yield of canola grown at Ballan in south west Victoria in 2007. The performance of these manures will be compared with equivalent rates of the lucerne pellets that were used in the earlier subsoil manuring experiments.

Methods

A field trial was carried out in 2007 on a Sodosol soil at Ballan in a high rainfall region of Victoria (long-term average annual rainfall 576 mm). The soil had a dense sodic subsoil (ρ_b = 1.4-1.6 g/cm^3; ESP=17-21%). The trial had a randomized complete block design with nine treatments (Table 2) in three replicated blocks. Each plot was situated on a raised bed (1.7 m wide) and was 10 m long, with a buffer bed between two treatment beds and a 3 m buffer space between two treatments on the same bed. Two beds were left as a buffer between blocks. The amendments (Table 1) were applied at the depth of 30-40 cm using a custom-modified twin-ripper implement, with a 20 cm diameter pipe located behind each ripper shank. An attached hydraulic-operated fan was used to move the materials down through the pipes. The organic amendments were fed into the pipes manually. The lucerne pellets contained 2.8% N, 0.9% P, and 1.4% K, poultry manure contains 3.2% N, 1.8% P and 2.1%K while pig manure contains 1.8% N, 1.2% P, and 1.3% K. Treatments were applied one week before sowing of the crop.

Canola (*Brassica napus*) was sown in mid June, 2007. Daily rainfall events in 2007 are presented in Figure 1. This shows that a dry spring occurred with minimal rainfall from mid-August to the end of October. Canola shoots, cut from a 0.5 m^2 quadrat, were sampled for biomass and N concentration determination on 19th September and at flowering on the 15th October 2007. The N concentration in a ground subsample of dried shoots was measured using an Elementar CN analyzer (Elementar Analysensysteme GmbH, Hanau, Germany). Grain yield was determined from mature shoots, harvested (15th Dec 2009) from the 0.5 m^2 quadrat, on the raised bed. Significant differences between treatments were determined by analysis of variance using Genstat 5 (Lawes Agricultural Trust, Rothamsted, UK).

Table 1. Description of the treatments used in the field trials

Treatment	Amendment	Rate (t/ha)
1	Lucerne pellets	5
2	Lucerne pellets	10
3	Lucerne pellets	15
4	Pig manure	5
5	Pig manure	10
6	Pig manure	15
7	Poultry manure	5
8	Poultry manure	10
9	Poultry manure	15
10	Control	Deep ripped only

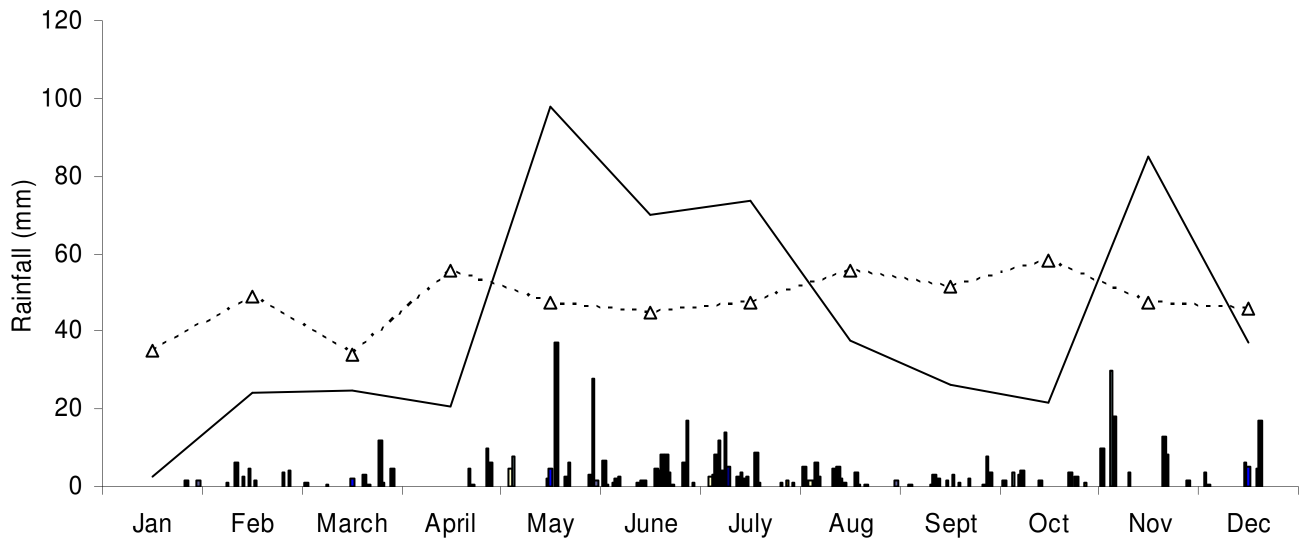

Figure 1. Daily rainfall events (bars) during 2007 at the trial site, together with the actual (continuous) and long-term monthly rainfall means (dashed lines).

Results and Discussion

Crop growth

The crop was sown late because of an infestation of annual ryegrass in paddock. Low temperatures followed during the winter months (maximum daily temperatures were around 12^{o}C while minimum temperatures were generally < 5^{o}C) with frequent frosts and one snowfall event. Germination and growth of crop were slow during this time. There was no differences in shoot biomass between treatments at the first harvest (mean 101 g/m^2), taken at rosette stage of growth. Biomass results (data not shown) for the harvest at flowering showed trends of increasing biomass in the treated plots, but no significant differences occurred.

Nitrogen concentration in canola shoots
There were no significant differences between treatments in shoot N concentrations at the 1st harvest (mean 5.1 %N). However there were differences between treatments and the control in the shoot N concentration at flowering (Figure 2). Here the three rates of the poultry manure had significantly higher shoot N concentrations ($P<0.05$) compared to the control, as did the two higher rates of lucerne pellets. No pig manure treatments differed from the control in shoot N concentration at flowering.

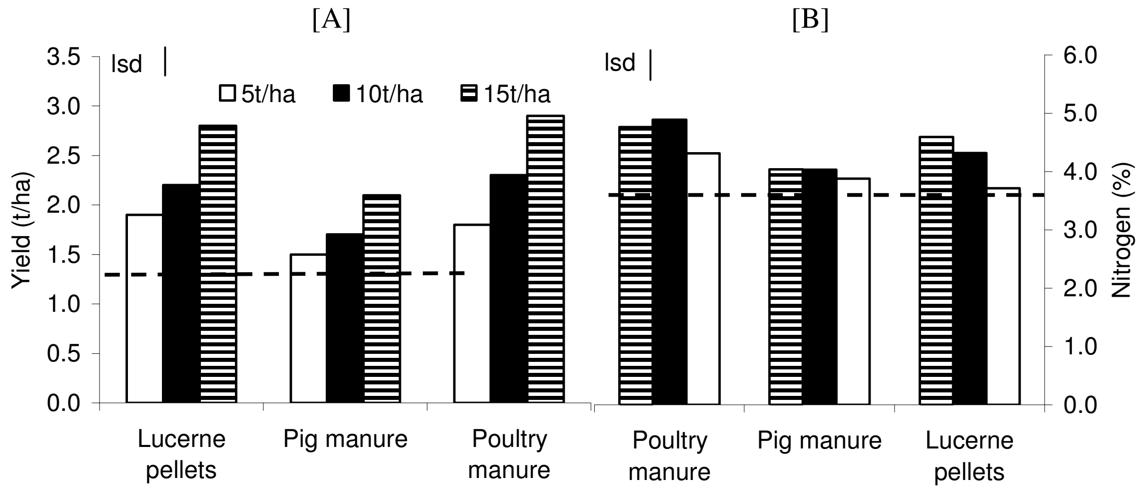

Figure 2. Canola grain yield (A) at harvest and the shoot N concentration at flowering (B). Dotted line shows values for the control treatment.

Crop performance and grain yield
Grain yield from the canola plots was significantly higher in all the organic-manure-treated plots, apart from the pig manure application of 5 t/ha. (Figure 2). Yields increased linearly with increases in rate of application of lucerne pellets and both manures from 5 t/ha to 15 t/ha. Increase in rate of application of pig manure from 10 t/ha to 15 t/ha also increased the yield significantly. The grain yield of canola was 115% higher with the 15 t/ha of lucerne pellets or poultry manure plots compared to the control plots (Figure 2).

The high rainfall events during May to July period (242 mm) would have increased the soil water status in the profile. This meant that there was adequate soil water to sustain the rapid increase in canola growth in all treatments in the early spring. However the dry conditions, resulting from the lack of significant rainfall events from late July to the end of October (Figure 1), began to restrict canola growth in the control plots during the mid spring period. Another subsoil manuring trial with canola had been established next to this field experiment, where access tubes for monitoring soil water with a neutron probe had been installed (Gill *et al.* 2008). Soil water measurements from the adjacent trial (data not presented) indicated that more soil water below the depth of 40 cm had been used by the canola plants from organic-amended plots, compared to the control plots, by the end of October. Thus it is likely that the canola plants in the organic-amended plots in this study were able to extract more subsoil water than the plants growing in the control plots. Large rainfall events occurred in early November during the latter part of the podfilling period (Figure 1); the canola plants in the organic-amended plots had not suffered any moisture stress prior to this rain and were able to benefit more from the rain. In contrast, the control plants had been showing symptoms of severe moisture deficit stress during October, and had begun to senesce when the November rain occurred. Consequently they did not respond to this late rain.

The poultry manure used in this study was equal in effectiveness to the lucerne pellets, when used as an organic amendment for subsoil manuring. This is encouraging for grain growers in the HRZ (High rainfall zone) as poultry manure is considerably cheaper and is more available than lucerne pellets. The pig manure however was less effective than the other two amendments, at all rates of incorporation. It is likely that the lower N concentrations in the pig manure reduced the N status of the canola plants relative to the other amendments (Figure 2), and this contributed to the lower canola yields.

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